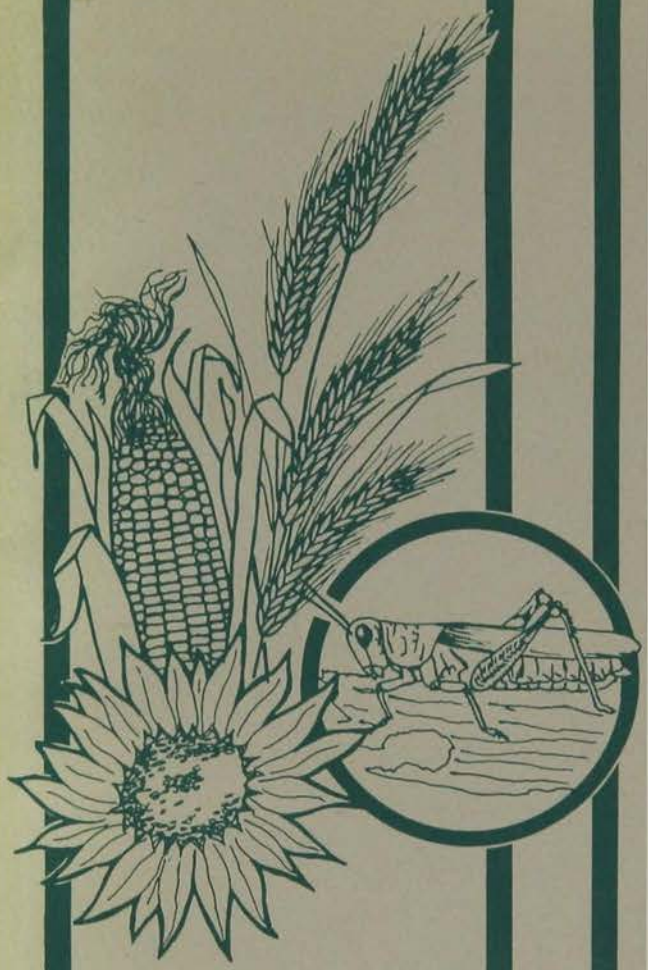

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Agricultural Extension Service
University of Minnesota

1985
Minnesota Pesticide Recommendations

Prepared by
Agricultural Extension Specialists
in Agronomy, Entomology, and
Plant Pathology

AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

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MINNESOTA PESTICIDE RECOMMENDATIONS

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ALFALFA WEEVIL UPDATE

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University of Minnesota

INTRODUCTION

Although alfalfa weevils (A.W.) have been present for at least 14 years in SE Minnesota and roughly 10 years in much of central and SW Minnesota, with their range gradually spreading north (see Fig. 1a), they have rarely been abundant enough to be a problem in this State. In 1984 a fortuitous sequence of favorable weather conditions was probably at least partially responsible for unusually high densities of larvae, and associated with this some economic damage, and on some farms, severe losses.

THE 1984 SEASON - SPRING

Heavy early snow and continuous snow cover which would have protected the ground from freezing for most of the winter of 1983/84, probably contributed to higher than usual overwinter survival of adult A.W. Normally A.W. eggs do not survive the winters in Minnesota. By late May A.W. adults and some larvae had been reported from several areas in the S & W of the State, and a warning was issued in the Plant Pest Control Newsletter alerting scouts to the possibility of a build up and advising them to start sampling alfalfa if they had not yet done so. Much of the first 2 1/2 weeks of June were rainy and overcast, delaying the first cut on many farms. By the 3rd week of June damage due to A.W. larval feeding, both on uncut alfalfa and on stubble regrowth, was being reported from a wide area (Fig 1b), with the most severe and widespread damage occurring in Dakota, Scott and Rice counties. Severe damage, skeletonizing the leaves of uncut hay, so that the crop has had a silvered appearance from a distance, and severely delaying regrowth after harvest, also occurred on a few farms in the other affected counties. Some farmers cut their hay early, before the rains, and in some cases desiccation and starvation reduced the numbers of A.W. larvae to non-economic levels. More frequently, the rain followed too soon after cutting for the farmers to pick up their hay, or else it prevented cutting altogether. Either way, young larvae were provided with a continuous supply of food in a moist and often sheltered environment, so they survived till later, less vulnerable stages, eating all the while. An unusually high number of farmers were forced to spray their stubble regrowth - a few also had to spray the standing crop, when it was too far ahead (> 10 days) of the planned harvest to cut the hay. This was the first time that A.W. damage to regrowth after the first harvest in Southwestern Minnesota had ever been severe enough to warrant chemical treatment. By the end of June the need for chemical treatment had largely passed, as the bulk of the larvae were pupating. When the new adults emerge, they normally feed for only a few days to a week or so before leaving the alfalfa for the summer.

PARASITES

Both parasites that attack the larvae (*Bathyplectes curculionis*) and others

that attack the adults (Microctonus aethiopoides) of A.W., have been released in the U.S. B. curculionis probably spread to Minnesota when the weevils came here, and its distribution now matches that of the weevils. USDA has released further B. curculionis in recent years to supplement the numbers. M. aethiopoides was released in SE Minnesota in the late 1970's but its establishment was not well documented. DUring spring 1984 Craig Krueger, a MS student with Dr. E.B. Radcliffe in the Department of Entomology, University of Minnesota, undertook a survey, sampling A.W. populations in Southern and East Central MN (Fig. 1b) to determine the distribution of the parasite M. aethiopoides. He brought samples of A.W. back to the laboratory and held them until the parasites emerged. He found that although the level of parasitism in about 1/2 the counties he surveyed is quite low, the parasites are now almost as widespread as the weevils. It appears, however, that more may have spread into Minnesota from Iowa or Wisconsin rather than from the local release.

1984 SEASON - FALL

Alfalfa weevil larvae are usually rare after about mid-July in Minnesota, there normally only being one generation a year here. In some years a very few larvae have been found in the fall, but not damaging numbers. A high (though variable) proportion of the adults produced from spring larvae leave the alfalfa fields in summer and neither feed nor reproduce until they return in the mid-to-late fall or next spring. The proportion leaving is influenced by condition of the alfalfa. We do not know what proportion of those that stay in the fields can reproduce without this 2-3 month physiological delay (called diapause). But this year, perhaps because of the exceptionally high numbers of weevil larvae in the spring, A.W. larvae were found in moderate abundance in some fields in Dakota and Goodhue counties during September. In one small field in Goodhue county numbers were so high that they caused damage well in excess of the spring treatment threshold. These larvae can only have been produced by weevils that did not diapause. There was not enough time (in terms of the day-degrees they require for development) for them to be the progeny of diapausing adults, even if the latter had by then returned to the alfalfa, which we do not know.

DISEASE

Larvae were collected from both the University of Minnesota Agricultural Experiment Station at Rosemount (September 6) and the severely damaged field mentioned above (September 14). A few of the former and all of the latter died of disease in the lab., and were found to be infected with a fungus Erynia that more often infests spring populations of alfalfa weevil. A number of the larvae had appeared sickly when collected. Workers in Champaign, IL are studying this disease organism but as yet we have no way to determine for sure whether it has any potential to be useful against A.W. in Minnesota - it is probably usually too rare here.

QUESTIONNAIRE

If we are to be better prepared for, and so more efficiently and economically handle problems with, alfalfa weevil in Minnesota in future we need a better understanding of the changes in its distribution and

abundance, and the factors influencing these changes. Firstly, however, we need to document what those changes were. In an attempt to collate all available information (albeit mostly qualitative rather than quantitative), in mid-October I sent a questionnaire style letter to County Agents, Area Agents and private consultants. Only about 15-20% of responses have been returned to date, with less than half of these coming from counties where alfalfa weevil damage was at its most severe and widespread. Consequently it is premature to draw conclusions from the replies at this stage. Nevertheless, it appears that the occurrence of relatively high numbers of A.W. larvae in the fall was much more localized than in the spring. Questionnaire responses have shown that A.W. is now present in 3 northern counties where the Minnesota Dept. of Agriculture (MDA) had not yet recorded it: Beltrami, Clearwater, and Cass. Likewise, Craig Krueger's samples showed that A.W. is present in Pine Co., also not recorded by MDA.

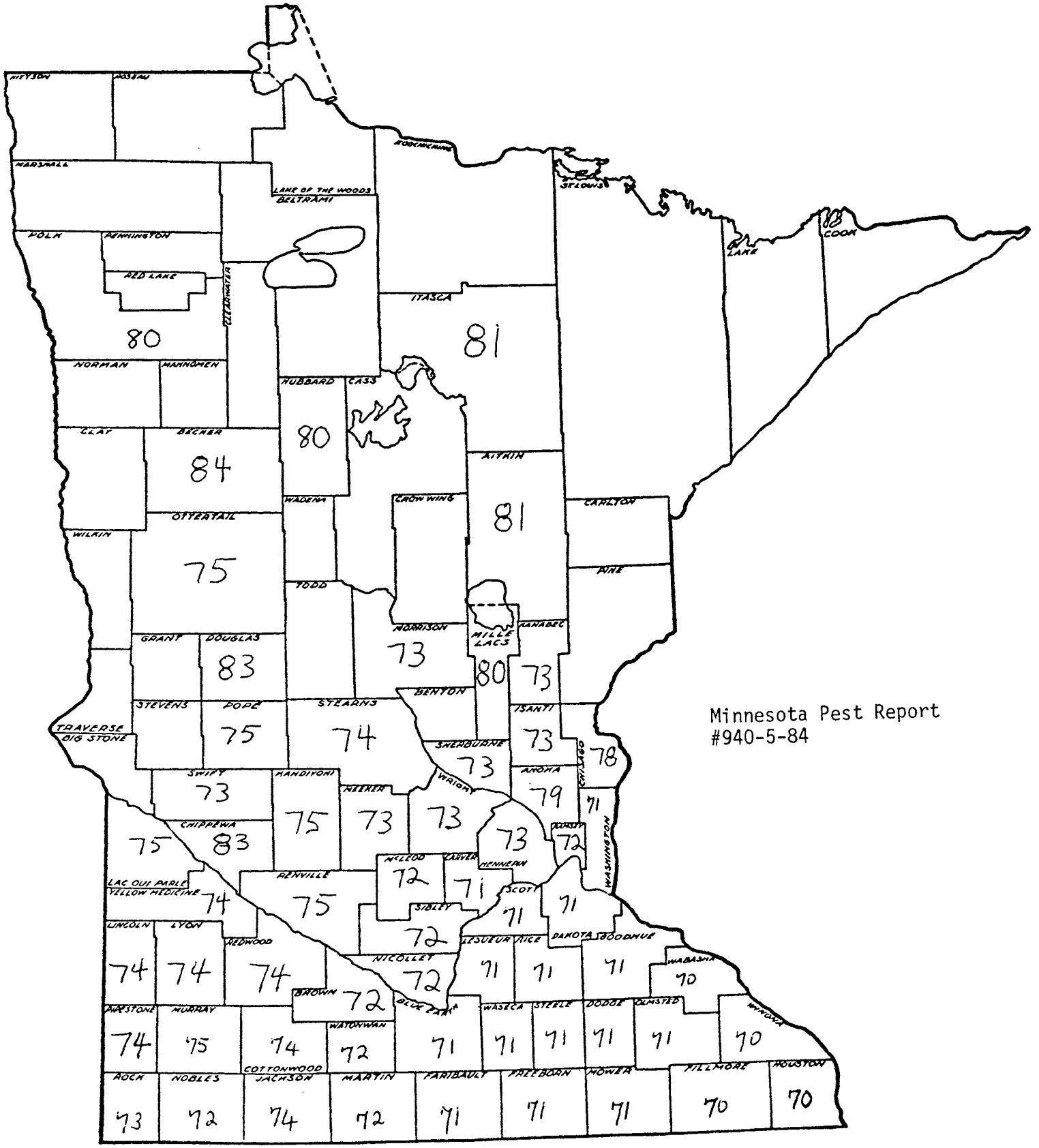
It is really important that all of us who have information on the alfalfa weevil collate it, so I am hoping for a high return rate on the questionnaires, once agents and consultants become less busy as the fall progresses. If any participants at this meeting feel they could provide information on the occurrence of the A.W. in Minnesota this season, I would welcome them contacting me for a copy of the questionnaire. The Extension Service fact sheet on the alfalfa weevil AG-FS-1026 will be updated before next spring.

CAPTION FOR FIGURES

Fig. 1a. Minnesota Dept. of Agriculture map showing years when they first recorded alfalfa weevil in each county of Minnesota.

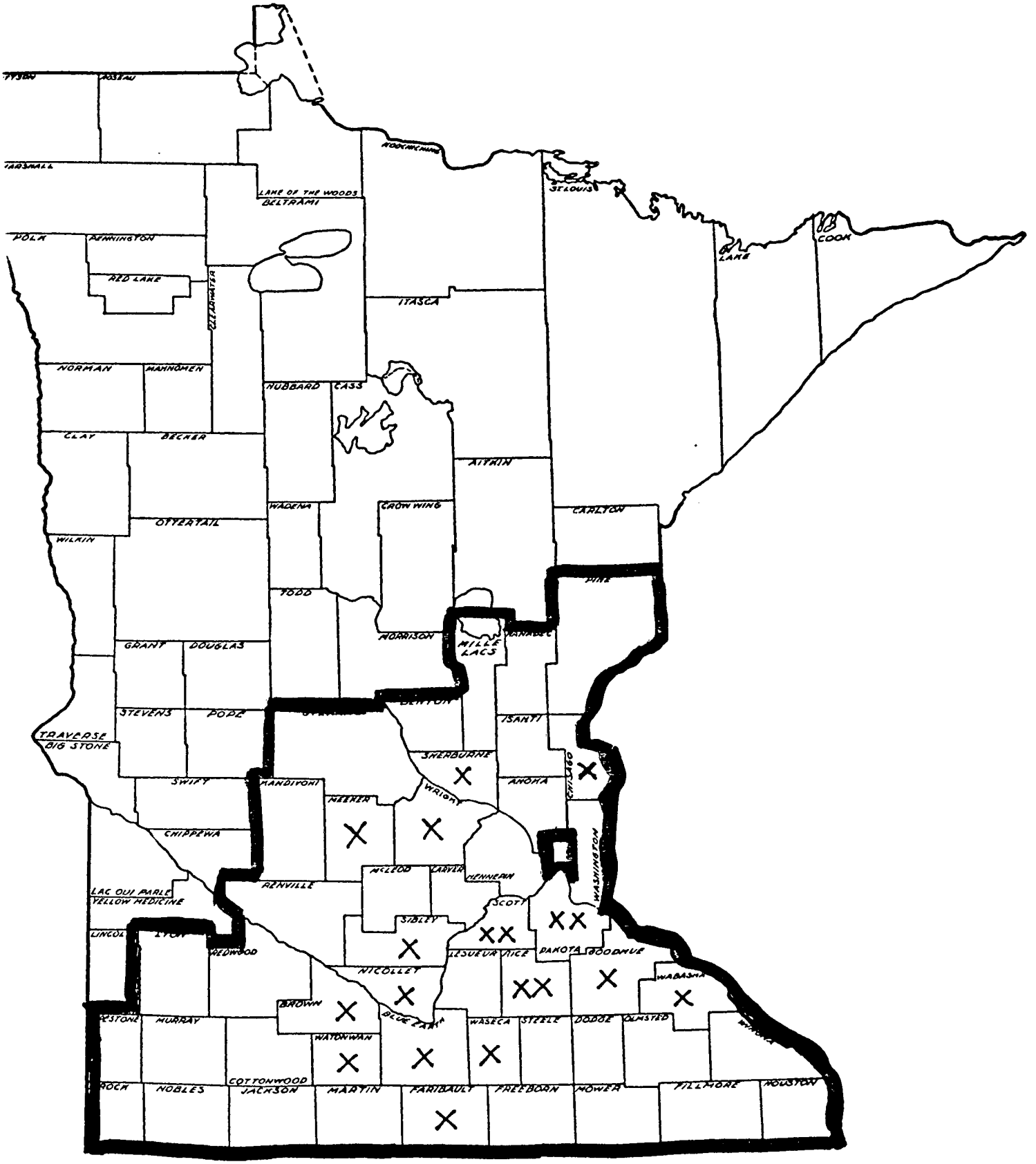
Fig. 1b. Area in south and east central Minnesota sampled by Krueger for alfalfa weevil and parasite Microctonus aethiopoides. X's mark the counties from which calls regarding alfalfa weevil problems were received - one X for few calls, 2 X's for many.

Figure 1 (a).



Minnesota Pest Report
#940-5-84

Figure 1(b).


LAKE OF THE WOODS
BELTRAMI
ITASCA
ST LOUIS
COOK
LAKE
RED LAKE
CLEARWATER
NORMAN
MAHNOMEN
HUBBARD
CASS
CLAY
BECKER
AITKIN
WADENA
CROW WING
CARLTON
OTTERTAIL
WILKIN
TODD
MORRISON
MILLE LACS
GRANT
DOUGLAS
STEVENS
POPE
TRAVERSE
BIG STONE
SWIFT
MEEKER
WRIGHT
ANOKA
CHIPPEWA
MCLEOD
CARVER
HENNEPIN
RENVILLE
LAC QUI PARLE
YELLOW MEDICINE
SCOTT
SIBLEY
LINCOLN
LYON
REDWOOD
LESUEUR
RICE
DAKOTA
GOODHUE
NICOLLET
WABASHA
BROWN
MURRAY
BLUE EARTH
WASECA
STEELE
DODGE
OLMSTED
WATONWAN
ROCK
NOBLES
COTTONWOOD
JACKSON
MARTIN
FARIBAULT
FREEBORN
MOWER
FILLMORE
HOUSTON

SAMPLING METHODS & ACTION LEVELS FOR ALFALFA WEEVIL IN MINNESOTA.

A monitoring and decision making method has been devised in Illinois that takes into account crop growth stage, intensity of infestation with alfalfa weevil, and progress of the infestation. As yet, however, this procedure has not been validated under Minnesota conditions. Until this has been done the following sampling methods and action levels are advised:

Sample Unit	# per Location	# of Locations	Action Level	Action Advised
(a) PRE - HARVEST				
Alf. stems collected at random	20	At least 5 per decision area	30-35% of stems show feeding damage in tip & larvae still active	If 10 days or less till planned harvest, & is possible to cut very soon, do so. Otherwise, spray with recommended insecticide (immediately if possible)
(b) POST - HARVEST - ON STUBBLE REGROWTH				
(i) Examine windrow areas:				
		5 per decision area	If regrowth is being retarded by feeding & A.W. larvae present	Spray as soon as possible with a recommended insecticide
(ii) If regrowth not being retarded take samples from both windrow & non-windrow areas				
Random square-ft. samples	2 wr & 2 non-wr	5 per decision area	8 larvae per square foot	" " " " " " " "

EUROPEAN CORN BORER SITUATION IN 1984

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Univeristy of Minnesota

INTRODUCTION

European corn borer populations reached record infestation levels in 1983. Statewide, economic losses attributed to the ECB through physiological loss, harvest loss, and chemical application costs exceeded $200 million. Infestation levels for the second generation and resulting harvest losses for 1983 are summarized in Table 1 (Data courtesy of the Minnesota Dept. of Agric. - Plant Industry Division). Based on historical patterns in the fall ECB survey, we projected that statewide infestation levels should decline in 1984. What was the ECB situation in Minnesota during 1984? Did infestation levels decline, as measured by the fall survey?

Table 1. Minnesota European corn borer fall survey results, Sept. 26-30, 1984. Data supplied by Minn. Dept. of Agric. - Plant Industry Division.

District	% Plants infested	# ECB larvae/ 100 plants	% shanks infested	# ears on ground
WC	90	241	44	7.2
C	79	178	40	4.6
EC	78	149	37	1.1
SW	95	295	64	1.5
SC	89	181	57	1.6
SE	92	241	59	1.6
State Average	87	214	50	2.9

THE EUROPEAN CORN BORER IN 1984

Spring surveys by the Minnesota Dept. of Agric. - Plant Industry Division revealed higher-than-normal levels of overwintering larvae, 11.3 larvae per 100 stalks. Despite high overwintering populations, the infestation potential of the population was not realized. Lighttrap captures of emerging adult moths remained within normal levels. Infestation levels were quite variable with treatment levels in some areas of SE, SC and NW Minnesota reaching 65-75% while treatment levels in some areas of SW Minnesota only reached 3-5%. Generally, infestation levels during first generation increased from west to east in southern Minnesota. Earlier planted, taller corn fields were hardest hit by ECB infestations.

The variability in infestation and poor realization of infestation potential seems related to heavy spring rains. These rains presumably reduced adult survival directly. Indirectly, these rains may have reduced larval

survival. The extensive rains during May and June interrupted corn planting and retarded corn development. Consequently, this "young" corn possessed higher levels of a resistance factor, called DIMBOA, that disrupts or prevents normal larval feeding. Low larval survivorship was commonly noted by consultants in SW, WC, and SC Minnesota.

Adult flights in northern Minnesota were comparable to last year at Crookston. As in southern Minnesota, the tallest and most advanced corn was more attractive for oviposition. Infestation levels were extremely high in some areas, reaching nearly 100% infestation and up to 8 larvae per plant. Infestation levels were highly variable but reduced from 1983. A partial second flight was observed at Crookston but all corn was sufficiently advanced to be unattractive for oviposition.

The second adult flight in 1984 was greatly reduced throughout WC, SW, and SC Minnesota. Infestation levels were reduced from 1983. The 1984 fall survey results are presented in Table 2. Generally, infestations were more severe in C, SC and SE Minnesota. Infestation levels, larval abundance, shank infestation, and ear droppage in SE Minnesota remained equivalent to 1983 levels. Except for the SE, infestation levels declined throughout Minnesota.

Table 2. Minnesota European corn borer fall survey results, Oct. 8-19, 1984. Data supplied by the Minn. Dept. of Agric. - Plant Industry Division.

District	% plants infested	# ECB larvae/ 100 plants	% shanks infested	# ears on ground
WC	63	84	15	0
C	75	111	20	1
EC	54	38	17	0
SW	36	38	5	<.5
SC	81	156	42	2
SE	93	224	52	2
State Average	67	108	25	1

TO TREAT OR NOT TO TREAT?

Economic thresholds presented in extension literature vary in form, depending on the quantity and quality of research used to derive them. First, if no research or experience exists for a particular pest situation, there are no thresholds. Second, a nominal threshold may be established from the learned opinion of an expert based on limited data. Third, a calculated threshold may be established from the following data:

1. the amount of damage expected from each pest individual,
2. the relationship between crop damage and yield loss,
3. the market value of the crop (yield x price), and
4. the cost of control and its efficacy.

Finally, weather effects on the crop, pest, and the yield-loss relationship can be incorporated into comprehensive economic thresholds.

Currently, most growers are familiar with older nominal thresholds for the ECB. These thresholds recommend treatment for first generation larvae when 50% of the whorls exhibit shotholing. Nominal thresholds are convenient because they remain fixed. However, nominal thresholds do not vary with crop price, yield expectations, or control costs. Consequently, they provide only an approximation of when it is economical to treat. Calculated thresholds are much more desirable, if data are available, because they are sensitive to economic factors. During 1983, new yield-loss data were released in a revised regional publication, entitled "Management of the European corn borer" - NCR publication no. 22, that made calculated thresholds for the ECB possible. These yield-loss values for various corn growth stages are presented in Table 3.

Table 3. Corn yield loss, expressed as percentage loss per borer, caused by European corn borer larvae for various corn growth stages. Adapted from Iowa and Kansas data presented in NCR publication no. 22.

Plant stage	% yield loss per borer per plant
Early whorl	5.5%
Late whorl	4.4
Pre-tassel	6.6
Pollen shedding	4.4
Kernels initiated	3.0

Economic thresholds for the ECB can be calculated from the following formula:

$$ET = \frac{\text{Control Costs}}{(\text{Expected yield} \times \text{crop price} \times \% \text{ loss/borer} \times \text{insecticide efficacy})}$$

where expected yield and crop price can be tailored to the specific farm operation, % loss per borer can be obtained from the previous table, and insecticide efficacy can be determined from insecticide trials. For the 1984 growing season, insecticide efficacy was set at 70% for first generation and 50% for second generation, pending generation of data specific to Minnesota.

WHERE'S THE MINNESOTA DATA?

Tailoring calculated economic threshold to Minnesota's ECB situation will require two types of research data, insecticide efficacy and yield loss per borer. This research problem is further complicated by Minnesota's climatic and cropping diversity. Two generations occur in southern Minnesota, which typically infest corn during the whorl stages (first generation) and during pollen shed and kernel initiation (second generation). In contrast, in northern Minnesota, the first generation infests corn during pretassel and

tassel stages. To generate realistic economic thresholds, efficacy trials and yield-loss experiments should be conducted in each of these situations. Research during 1984 focused on efficacy trials against the first generation in both southern and northern Minnesota and on the yield-loss relationship in northern Minnesota. Research plans for 1985 include the expansion of yield-loss studies to southern Minnesota for both generations and the expansion of efficacy trials to include the second generation. Within the efficacy trials, data will be generated on the relative performance of individual insecticides and formulations (granules vs liquid sprays), and on the appropriate timing of applications for optimal effectiveness.

INSECTICIDE PERFORMANCE DURING 1984

During 1984, three insecticide trials were established against first generation larvae. The first trial, located at the Southern Experiment Station in Waseca, explored the performance of all labelled granular materials under field conditions. All insecticides were applied with a Gandy airblast applicator mounted on a hi-boy sprayer on July 6. At the time of application, ca. 48% of the plants were infested with 2.85 larvae per infested plant, producing a field average of 1.4 larvae per plant. Corn was at the 13 leaf stage and ECB larvae ranged from first to fourth instar. All granular insecticides performed well, averaging 90.9% and ranging from 83.1% to 97.4% (Table 4).

Table 4. First-generation European corn borer control by granular insecticides. Waseca Co. - Southern Expt. Stn.

Treatment	Rate (lbs ai/A)	Tunnels per 20 plants	% control
Furadan 15G	1.00	0.67 b	97.4
Dipel 10G	1.00	1.00 b	96.1
Lorsban 15G	1.00	2.00 b	92.2
Dyfonate 20G	1.00	2.33 b	90.9
Diazinon 14G	1.00	3.67 b	85.7
Counter 15G	1.00	4.33 b	83.1
Untreated check	----	25.67a	

The second and third trials were located near Crookston at the Northwest Expt. Stn. and near Thief River Falls at the Bob Wald farm, respectively. These trials, involving a matched set of compounds, explored the performance of all labelled and soon-to-be labelled compounds. At both locations treatments were applied by hand on July 23 to corn which was just tasseling. The infestation level at Crookston averaged 73% with 3.8 larvae per infested plant for a field average of 2.8 larvae per plant. The infestation level at Thief River Falls averaged 58% with 4.2 larvae per infested plant, for a field average of 2.4 larvae per plant. At both sites, larvae ranged from first to third instars. The performance of compounds in these trials,

revealed by the number of tunnels, is presented in Table 5. Insecticide effectiveness varied considerably from 17.1% to 76.8%. Efficacy for granular insecticides averaged 64.0% while efficacy for liquid sprays averaged 41.0%. Thus, granular formulations seem to provide slightly better control than liquid sprays, even on tasseling corn.

Table 5. Effectiveness of granular and liquid-spray insecticides on first-generation European corn borer in northern Minnesota. Polk Co. - Northwest Expt. Stn. and Pennington Co. - Bob Wald farm.

Treatment	Rate (lbs ai/A)	Tunnels per 5 plants TRF *	Crookston	Average	% Control
Granules					
Pounce 1.5G	0.15	4.00 g	4.75 c	4.38	76.8
Diazinon 14G	1.00	4.50 fg	6.00 bc	5.25	72.1
Furadan 15G	1.00	5.50 efg	6.50 bc	6.00	68.2
Lorsban 15G	1.00	6.75 defg	6.75 bc	6.75	64.2
Counter 15G	1.00	7.75 defg	6.25 bc	7.00	62.9
Dyfonate 20G	1.00	6.00 defg	9.50 bc	7.75	58.9
Thimet 20G	1.00	8.00 defg	8.25 bc	8.13	56.9
Dipel 10G	1.00	7.25 defg	11.00 b	9.13	51.6
Liquid sprays					
Furadan 4F	1.00	9.63 cde	8.75 bc	9.19	51.2
Penncap-M 2E	0.50	8.75 def	10.25 bc	9.50	49.6
Pounce 3.2E	0.15	10.00 cd	9.00 bc	9.50	49.6
Pydrin 2.4E	0.15	12.88 bc	10.75 b	11.82	37.3
Lorsban 4E	1.00	14.00ab	17.25a	15.63	17.1
Untreated check	----	17.75a	19.94a	18.85	

* TRF designates Thief River Falls.

CONCLUSIONS FROM 1984

1. Labelled granular insecticides provide effective control of first-generation ECB larvae in southern Minnesota. Efficacy ranged from 83% to 99%. These data suggest that a conservative value of 85% should be used in 1985 economic threshold calculations.
2. Both granular and liquid insecticides provide reasonable control of first generation larvae in northern Minnesota. Efficacy ranged from 17.1% to 76.8%. On the average, granular insecticides outperformed liquid insecticides by ca. 20%, 64% vs 41%, respectively. Results of these trials suggest that efficacy values of 60% and 45% be used for granular and liquid insecticides respectively, in economic threshold calculations.
3. Shotholing provides a poor criteria for treatment decisions in northern Minnesota. Egg laying and egg hatch occurs when corn is

in the late whorl to tassel stages. Leaf feeding damage at these stages is very subtle and leaf collar feeding is very difficult to detect. Treatment decision criteria, at a minimum,should include both shotholing and egg masses. Alternatively, close examination of leaf collars and tassels can yield an accurate determination of larval abundance. This approach offers the distinct advantage of providing a reliable indicator of larval development and feeding position, necessary information to insure timely insecticide application.

CORN ROOTWORM INSECTICIDE PERFORMANCE IN 1984

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University of Minnesota

INTRODUCTION

The combined strategies of crop rotation and soil insecticide use in continuous corn usually limit corn rootworm damage effectively. Each year farmers report the poor performance of soil insecticides. During 1984, these reports of poor performance were unusually abundant and involved all soil insecticides. During recent years, the apparent failure of some soil insecticides with continuous use (e.g. carbofuran, isofenphos) has generated concern about the continued performance of all soil insecticides. Are the widespread reports about poor performance in 1984 related to enhanced microbial breakdown? What other factors affect the performance of soil insecticides? What can a farmer do to improve or maintain the performance of soil insecticides?

SOIL INSECTICIDE PERFORMANCE

Poor insecticide performance, per se, does not indicate enhanced microbial breakdown. Rather, various factors affect the performance of soil insecticides against the CRW. Soil insecticides applied at planting need to be present in sufficient amounts and in the right place to provide control of larvae that hatch 30 to 50 days later. Any factors that affect the timing of corn planting and larval hatch, the placement and amount of insecticide applied, or the degredation of the insecticide in the soil can alter the insecticides performance. In the next few paragraphs I'll highlight some of the factors that affect soil insecticide performance.

Proper application

Proper application is the most important factor the farmer has within his control. For optimum performance, each granular applicator should be calibrated to insure the proper rate is applied. Calibration should be repeated each year because wear can increase flow rate. The insecticide should be applied in a 6-8" band as close to the soil surface as soil conditions and equipment will allow. Dropping insecticide from greater heights will allow wind drift to occur. Wind can dramatically alter the application pattern, shifting the band up to 8" from its intended center over the row. Finally, shallow incorporation, ca. 1/2", is necessary for proper movement of some less-soluble insecticides into the root zone.

Rainfall

Rainfall can affect insecticide distribution and persistence. Heavy rains that produce extensive sheet and rill erosion just after planting can dramatically alter the distribution of insecticides. Erosion can be particularly heavy in the press wheel track, depending on row orientation

and slope. Percolating rain can leach the more-soluble insecticides further into the soil profile. Finally, moisture can enhance the degradation of insecticides by chemical reaction (hydrolysis) or by promoting the growth of insecticide-degrading soil microflora.

Delayed CRW egg hatch

Soil insecticides applied at planting are constantly degraded in the soil environment. Proper control of CRW larvae depends on a sufficient residual of the insecticide present in the soil when the larvae hatch in late June. Cool soil temperatures that occur through cooler than normal air temperatures, cloudiness, and/or rainfall may retard CRW development and egg hatch. This delay would permit additional insecticide degradation and could result in reduced insecticide performance.

Population pressure

Insecticides rarely kill an entire insect population. The proportion of the population killed varies with the insecticide concentration in the environment. Assume the effectiveness of an CRW insecticide is 90% under normal field conditions, planting dates, and CRW hatching dates. Damage resulting from a CRW population would depend on the size of the egg population in the soil. If 100 eggs occurred in each quart of soil, 10 larvae would be expected to survive. If 10 eggs occurred in each quart, only 1 larvae would survive. In both cases, the insecticide performed equally well yet the damage in the first case would be greater than in the second case. Thus, the size of the egg population in the soil can affect insecticide performance, in terms of crop damage.

Tillage

Preliminary data indicate tillage may affect the resulting level of damage. Data from Iowa and Minnesota suggest that some tillage systems (no-till, chisel plow) suffer greater damage than other tillage systems (conventional, ridge-till). The data are not definitive at this point. Considerable research is underway on this topic and on the effects of residue and incorporation on insecticide performance.

Resistance

At this point there is no evidence to suggest that resistance mechanisms are involved in recent examples of poor performance.

Enhanced biodegradation

Repeated use of some soil-applied insecticides and herbicides can lead to enhanced biodegradation. Some soil microorganisms can adapt to feed on the soil insecticide as a food source. Repeated use of an insecticide can favor the proliferation of these microrganisms. Under these conditions the insecticide concentration in the soil declines more rapidly and insufficient amounts are left at CRW hatch to provide control. Laboratory studies have demonstrated that soils can become agressive degraders of organophosphate

and carbamate insecticides in as little as 1 to 2 applications. Field documentation of enhanced biodegradation has been demonstrated for both carbamate and organophosphate insecticides. Cross reactivity between insecticides with the same chamical class has also been demonstrated. These findings suggest that we exercise caution in the use of soil insecticides. Rapid degradation of soil insecticides could become a major problem affecting both carbamate and organophosphate insecticides. The problem of micorbial degradation is a complex one requiring more research. Rapid breakdown of insecticides does not occur in every field with a continuous use pattern. The factors which promote enhanced degradation in some cases but not in others need to be understood.

PERFORMANCE OF SOIL INSECTICIDES IN 1982 TRIALS

The performance of CRW insecticides was evaluated at three locations, Waseca, Lamberton, and Morris. Both Lamberton and Morris experienced excellent pressure from CRW populations, receiving root ratings of 3.40 and 4.00, respectively, in the untreated checks. CRW pressure at Waseca was greatly reduced, as compared to previous years, with the check receiving a root rating of only 1.82 Table 1 presents the results of these trials for labelled compounds and compounds with an experimental use permit (Lance 20G). Please note that Amaze 20G is no longer marketed.

Table 1. Performance of soil insecticides on the corn rootworm in Minnesota during 1984, as measured by root damage ratings (Iowa 1-6 rating scale).

	Average Root Ratings		
Treatment	Morris	Lamberton	Waseca
Lance 20G	1.98 f	1.63 c	1.15 d
Lance 20G *	2.18 ef	1.68 c	1.13 d
Counter 15G	2.68 de	1.80 c	1.13 d
Amaze 20G	2.55 e	2.33 b	1.63ab
Thimet 20G	2.65 de	2.38 b	1.30 cd
Broot 15G	3.18 cd	2.63 b	1.13 d
Dyfonate 20G	3.38 bc	2.85 b	1.25 d
Mocap 15G	4.03a	2.35 b	1.28 d
Furadan 15G	3.73ab	2.68 b	1.53 bc
Lorsban 15G	3.68abc	2.85 b	1.68ab
Untreated Check	4.00a	3.40a	1.81a

*All treatments applied at 1.0 lbs ai/acre with the exception of one Lance treatment at 0.75 lbs ai/acre. All treatments applied as a 7" surface band behind the presswheel, with the exception of Lorsban 15G which was applied ahead of the presswheel. Planting dates: Morris - May 11, Lamberton - May 22, Waseca - May 17. Roots rated: Morris - Aug. 1, Lamberton - Aug. 2, Waseca - July 26.

The poor performance of some compounds may be related to extensive rainfall which leached more soluble compounds deeper into the soil than desired, promoted degradation, and delayed CRW hatch about 7-10 days later than normal.

CONSISTENCY OF CRW INSECTICIDE PERFORMANCE

Corn rootworm insecticides vary in the consistency of their performance. Consistency may be measured in two ways. First, a root rating of 3.00 is considered the threshold of economic damage. Consistency can be measured as the proportion of time the insecticide produces a damage rating less than 3.00. Second, insecticide performance can be judged relative to the best insecticide in each trial. In this case, consistency is measured as the proportion of trials where the insecticide produced a root rating statisitically comparable to the best insecticide. Consistency of CRW insecticide performance during recent years (1977-1984) is presented in Tables 2 and 3 respectively.

Table 2. Corn rootworm insecticide performance in Minnesota, 1977-1984, as measured by root ratings < 3.0.

Compound	# Ratings < 3.0 / # Trials	%
Counter 15G	19/20	95
Thimet 20G	18/19	95
Broot 15G	16/17	94
Amaze 20G	17/19	89
Dyfonate 20G	15/19	79
Furadan 15G	15/20	75
Mocap 15G	13/19	68
Lorsban 15G	10/19	53
Check	4/20	25

Table 3. Corn rootworm insecticide performance in Minnesota, 1977-1984, as measured by statistical equivalence to best insecticide.

Compound	Times equivalent to best compound	%
Counter 15G	14/15 *	93
Thimet 20G	13/14	93
Amaze 20G	14/15	93
Broot 15G	10/12	83
Furadan 15G	9/15	60
Dyfonate 20G	8/14	57
Mocap 15G	7/14	50
Lorsban 15G	4/14	29
Check	2/15	13

* Number of times statistically equivalent to best compound divided by the total number of trials containing the compound. Trials where check root rating did not exceed 3.00 were excluded.

SITUATION FOR 1985

Results of the adult corn rootworm survey conducted by the Minnesota Department of Agriculture - Plant Industry Division are presented in Table 4. Adult beetle numbers declined in the WC, SC, and SE districts. Despite this decline from 1983 levels, the beetle counts in each district exceeded 2.0 beetles per plant. With these population levels the potential clearly exists for economic damage in continuous corn fields. The ratio of northern CRW (Diabrotica longicornis) to western CRW (D. virgifera) remains the same as last year 91:9.

Table 4. Corn rootworm adult survey (Aug. 6-15) in Minnesota.

District	Fields	Corn plants per acre	CRW beetles/acre 1983	CRW beetles/acre 1984	Percent lodging
WC	35	20,736	70,898	41,324	2.1
C	43	21,927	43,533	42,428	0.8
EC	25	21,917	9,255	42,451	0.0
SW	29	21,321	54,892	54,346	1.6
SC	30	22,878	52,318	46,866	3.1
SE	23	23,211	67,310	51,522	4.0

RECOMMENDATIONS FOR 1985

The best management strategy against CRW injury is crop rotation. For those growers who need to grow continuous corn for livestock or economic reasons, the use of soil insecticides is recommended if no scouting for CRW adults was done during August, 1984. If fields were scouted in 1984 and bettle counts averaged more than 1.0 beetle per plant, treatment with a soil insecticide is recommended. No treatment is necessary if beetle counts averaged less than 1.0 beetle per plant.

The continuous use of any soil insecticide has the potential to encourage enhanced biodegradation and poor performance. We do not know how frequently soil insecticides should be changed or the pattern of use that should be followed. However, the following recommendations seem prudent:

1. Make sure that your equipment is applying insecticides correctly. Check the calibration, application pattern, and incorporation. Do not plant under extremely windy conditions to avoid wind drift.
2. Avoid the continuous use of one soil insecticide. Rotate insecticides, especially if poor performance occurs. A rotation between insecticide classes, carbamates (Broot, Furadan, Lance) and organophosphates (Counter, Dyfonate, Lorsban, Mocap, Thimet) may be advisable.

Cutworm Control

Our interest continues in comparing newer chemicals against those which have performed well in cutworm control. In past years our trials have included control of dingy, darksided and redbacked cutworms. Populations of these three species were low in 1983 and 1984. However, the PIK program apparently contributed to huge local populations of sandhill cutworm (Euxoa detersa Walker) in Morrison County. Such a local outbreak permitted a trial against this cutworm species at the Sundvahl farm (Table 1) near Royalton.

The cutworm itself prefers to oviposit in grains in the fall. The Morrison county outbreaks were associated with rye planted PIK acres. On one farm we visited with the county agent, the cutworm destruction of corn following PIK was exactly to the edge of the 1983 rye planting. Eggs hatch in the fall, larvae winter and were in the third and forth instars when these plots were established on May 30, 1984. The literature reports this species as a subterranean feeder but this has to be incorrect as evidenced by our trial results. The larvae are pale colored and translucent so stomach contents are visible.

Table 1

SANDHILL CUTWORM CONTROL - MINNESOTA 1984
Morrison County - Sundvahl Farm
David M. Noetzel

Treatment	Dosage in pounds ai/A	Average number dead larvae/6 rows: post treatment
Lorsban (4E)	1.0	19.0
Baythroid (2E)	0.025	15.7
PP321 (1E)	0.01	14.6
Pay-Off (2.5E)	0.05	6.7
Pydrin (2.4E)	0.1	4.0
Ammo (2.5E)	0.05	4.0
Pounce (3.2E)	0.1	3.7
Sevin XLR (4E)	2.0	2.3
Dyfonate (4E)	4.0	1.7
Dyfonate (4E)	2.0	1.7
Untreated	-	0

The main portion of this field was from 30 to 80% destroyed by the sandhill cutworms. The grower had to replant and used granular Lorsban 15G at one pound actual per acre. We examined this field a week later (June 8, 1984) when portions of it again had stand reduction in excess of 50%. Cutworm feeding was going on everywhere in the field at that time. This convinced us that granulars are not effective enough to recommend for cutworm control. In most cases a broadcast spray appears the preferred, and possibly only, choice.

Our cutworm trials were placed in this corn field. We have always broadcast the treatments in about 10-15 gallons of water per acre. Plots were 9 rows x 30' in length and replicated three times. We did not disturb the soil surface following application. Readings were taken twenty four hours following treatments.

It was apparent at 24 hours post treatment that feeding had essentially ceased in the Lorsban, Baythroid and PP321 plots. This continued so corn stands had not changed between May 31 and June 8 in these plots in contrast to the "failure" in the main field.

We have had better performance of Pydrin and Pounce in years past on other cutworm species. This was our first work with the sandhill cutworm and also our first trials on sand. We cannot tell from these data why performance of these compounds was unacceptable.

I would like to acknowledge the excellent cooperation of Hal Sundvahl and the early call from James Carlson and Ken Olson which permitted these trials.

Armyworm 1984 and Control Trials

Armyworm provided considerable excitement again in 1984. The 1983 outbreak, although smaller in size, suggested that there was maldistribution of insecticide in Minnesota and some areas of the state had inadequate numbers of applicators. We also were slow to diagnose infestations "on the ground" in 1983 even though light trap collections suggested potential problems.

In 1984, an augmented light trap analysis by the Minnesota Department of Agriculture (Dr. Dharma Sreenivasam) and the Area Extension Agents-Integrated Pest Management (Rick Gauger and Carlyle Holen) gave an early indication of problem potential. Adult armyworm counts were exceedingly high in the southeastern and south central parts of the state. On the basis of these trap catches we indicated almost to the day when feeding damage should first be observed.

In the meantime, in view of the apparent lack of availability of insecticide in 1983, we contacted the Minnesota Department of Agriculture indicating we would request a special exemption for Lorsban 4E. If it did not come before the anticipated armyworm problem we would make a crisis request to insure adequate availability of insecticide. Such a request was possible in view of our work with Lorsban the past 8 to 10 years.

A third, and perhaps fortuitous event, was the rainy period during weed spraying. The Department of Agriculture permitted licensing of additional applicators to cope with this need. More importantly, weed spraying provided work for our locally based applicators and held them here continuously until the armyworm outbreak surfaced. (Fig. 1)

County agents, area agents and private consultants were able to detect early "on the ground" numbers of armyworm larvae that exceeded 50 per square foot in some fields. Indeed, these early observations led to the contacting of extension specialists and permitted some excellent insecticide trials (Tables 2 and 3).

In my fourteen years at Minnesota this is the first time that treating was begun when larvae were second and third instar and was largely completed before armyworm migration was observed. My hat is off to the entire industry for early detection, availability of chemical and expedient application. We estimate that these preparations and prompt action led to a saving for Minnesota producers of approximately 20.6 million dollars. This is based on 575,000 infested acres of which 350,000 were treated.

Fig. 1 ACRES INFESTED BY ARMYWORM 1984

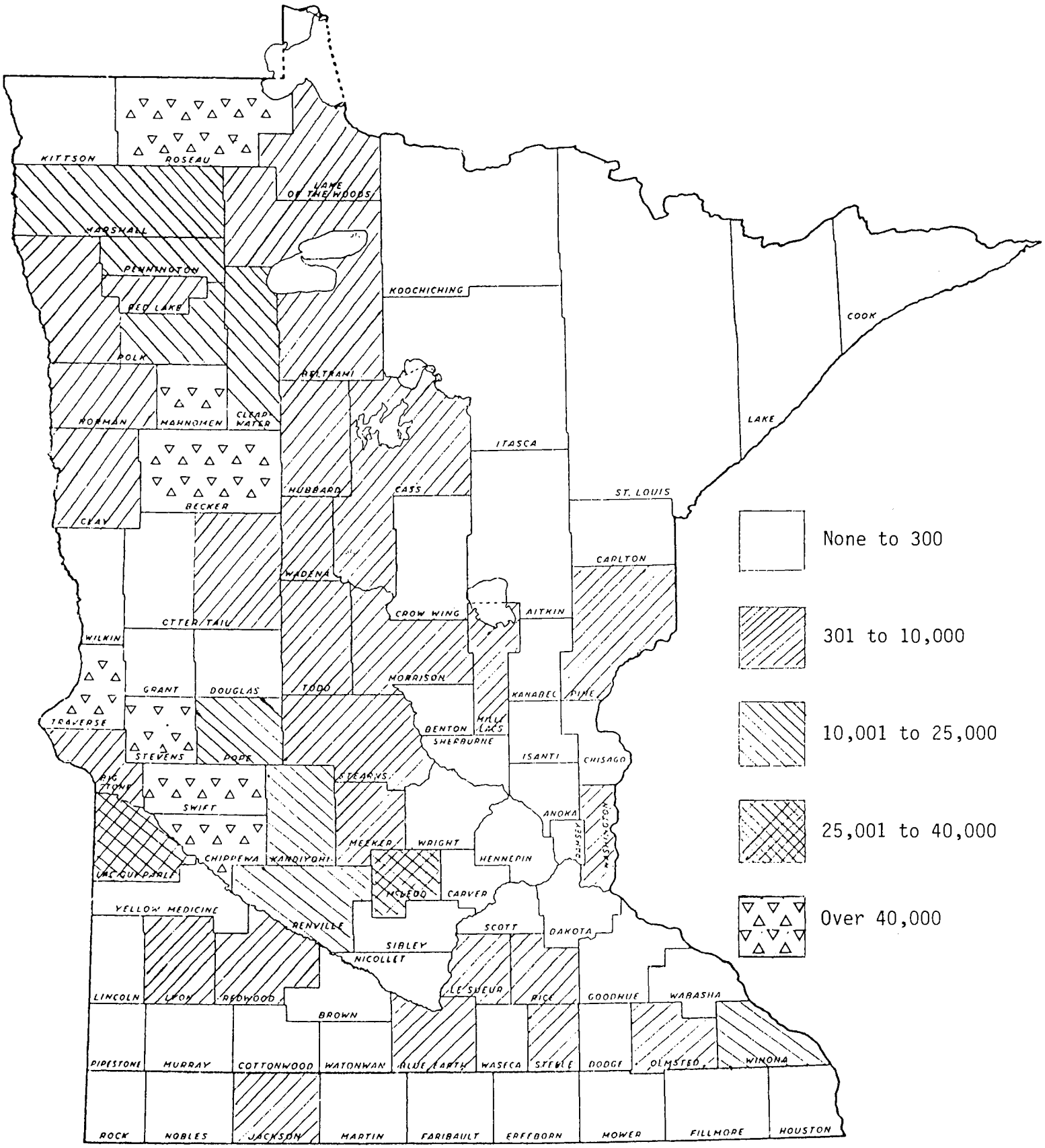

Table 2

ARMYWORM CONTROL - MINNESOTA 1984
Chippewa County - Norm Bosch Field
David M. Noetzel

Treatment	Dosage in lbs. ai/A	Average per cent control
Penncap-M (2E)	0.5	100
Pounce (3.2E)	0.1	100
PP321 (1E)	0.1	97.1
Pydrin (2.4E)	0.1	95.7
Cymbush (3E)	0.04	95.7
Pay-Off (2.5E)	0.04	92.9
Baythroid (2E)	0.04	92.9
Lorsban (4E)	0.5	92.9
Sevin XLR	1.5	91.4
Spur (2E)	0.04	78.6
SN 415	2 pts.	64.3
ABG 6162A	2 pts.	4.3
Untreated	-	0

Table 3

ARMYWORM CONTROL - MINNESOTA 1984
Becker County - Les Hanson Field
David M. Noetzel

Treatment	Dosage in pounds ai/A	Average per cent control
Pounce (3.2E)	.1	99.3
PP321 (1E)	.04	96.7
Pay-Off (4E)	.04	95.3
Lorsban (4E)	.5	94.7
Baythroid (2E)	.04	92.7
Pydrin (2.4E	.1	86.7
Cymbush (3E)	.04	84.3
Sevin XLR (4S)	1.5	80.0
Dyfonate (4E)	4.0	74.7
Spur (2E)	.04	45.3
ABG 6162A	4 pts	28.7
SN 415	4 pts	6.3
Untreated	-	3.7

Insecticide trials against armyworm were set out in Chippewa and Becker counties. The larval counts were 46/sq. ft. and 25/sq. ft. respectively in the two tests. We included two biologicals (SN415 and ABG6162A) along with several pyrethroids, one phosphate and one carbamate. Materials were broadcast on plots 30' square at the rate of 10-15 gallons of total material per acre. Larval counts were taken pre and 24 or 48 hours post-treatment. Results are expressed in per cent control.

Its our impression that growers will not accept less than 90% or better control. Our trials suggest that Sevin XLR, Spur, Dyfonate and the biologicals tested will not provide larval reduction acceptable to producers.

We would make the observation that when larval counts, or evidence (feces) thereof, equal or exceed 5 armyworm larvae per square foot one should not wait to see what damage is going to occur. Daytime counts of 4 to 5 larvae per square foot will almost certainly have nighttime larval numbers much higher than the 5 larvae per square foot action level. Do not wait to treat such a field with the recommended insecticide.

Finally, we have not yet been informed of a regular label for Lorsban use against armyworm. We know it performs equal, or superior to, presently labeled compounds (Penncap M, Lannate, and Dylox) for armyworm control. When Dow obtains this label we will let the industry know.

Sunflower Beetle Larval Control

Sunflower beetle populations collapsed in 1984. This unpredictability alone should discourage preventive soil systemic treatments for this insect. (Data supporting this observation will be discussed under soil systemic trials.) In fact, beetle populations were so low that we spent considerable effort in locating fields with larval numbers over 5 per plant for our trials.

Two (Table 4 and 5) of four 1984 sunflower beetle control trials are reported here. All applications were broadcast in 10 to 15 gallons of total material per acre. Plots are 2 or 4 rows and 25 feet in length replicated four times. In addition, but not included here, was an aerial trial at Benson using 1/100 lb of Pydrin in 3 gallons of total material per acre. Counts were taken at 24 and 96 hours and control is reported as per cent reduction based on the untreated check in each replicate.

In Table 4 insecticide effectiveness of 9 pyrethroids, 5 phosphates, 4 carbamates, 2 biologicals and 1 chlorinated hydrocarbon are compared. In most cases much lower then registered dosages were used. Note the excellent performance of all the pyrethroids at these lower rates.

Table 4

SUNFLOWER BEETLE LARVAL CONTROL - MINNESOTA 1984
Norman County - Moen Field
David M. Noetzel

Treatment	Dosage in lbs ai/A	Average per cent control
Ammo (2.5E)	.005	99.3
Cymbush (3E)	.005	98.6
PP321 (1E)	.005	97.5
Supracide (2E)	.25	97.5
Pounce (3.2E)	.01	97.1
Furadan (4F)	.125	95.0
Baythroid (2E)	.005	94.6
Pydrin (2.4E)	.01	92.9
Pay-Off (2.5E)	.005	91.8
Spur (2E)	.005	91.4
Ambush (2E)	.01	90.4
BAS 263 (40 oz/liter)	.125	88.9
Thiodan (3E)	.25	85.0
Sevin XLR (4E)	.5	82.5
Larvin (3.2E)	.25	68.2
Lorsban (4E)	.25	54.3
Dylox (80wp)	.25	43.2
Cygon (4E)	.125	41.1
Penncap M (2E)	.25	38.9
ABG 6162A	4 pts.	30.7
San 410	1 pt.	22.1
San 410	2 pts.	21.4
San 410	4 pts.	12.5
Untreated	-	0

Pydrin, which has a sunflower label for 1985, provided excellent broadcast control (92%) at 1/100 of a pound actual per acre. This has been consistent for the last three years as well as in several 1984 (see also Tables 5, 6, and 7) tests. We will recommend Pydrin at somewhere between 0.03 and 0.01 lbs ai/A for sunflower beetle larval control in 1985. For growers who can apply Pydrin for sunflower beetle control at last cultivation (plant height 8-15 leaves) a directed spray over the row should permit rate reductions even greater than this.

Of the insecticides presently registered on sunflower Pydrin at 0.03-0.01 lbs/A, Furadan at 0.125 lbs/A and Supracide at 0.25 lb/A all provide excellent sunflower beetle larval control. Control rates for these compounds at the above rates has been above 90% in all trials the last three years.

In addition, we remain interested in as economical and predictable control as we can obtain. In examining this concept we lowered dosages still further (see Table 5) in a trial in Swift county in a field with about 62.5 larvae per plant. The percentage reduction for each date (one day and four day post treatment) are based on the number of living larvae per plant in untreated plots (62.5 and 38.4 respectively) on the day of the reading. Note that in all cases per cent control increases over the 96 hour period following treatment. And note especially how Pydrin performs at 0.01 and 0.005 lb ai/A.

Table 5

SUNFLOWER BEETLE CONTROL - MINNESOTA 1984

Swift County - Carruth Field

David M. Noetzel

Treatment	Dosage in lb. ai/A	Average per cent control at: 1 day	4 days
Pydrin 2.4E	.01	94.4	99.8
	.005	93.1	100.0
	.0025	81.2	88.6
	.00125	52.1	82.6
	.0005	35.0	64.3
PP321	.005	94.1	100.0
	.0025	88.4	98.0
	.00125	84.1	98.0
	.0005	81.5	97.9
Cymbush	.005	93.3	97.0
	.0025	85.5	98.6
	.00125	79.1	95.5
	.0005	62.4	91.7
Pounce	.01	84.0	95.8
	.005	53.7	88.2
	.0025	38.2	76.4
	.00125	43.1	72.0
	.0005	25.2	59.7
Untreated		0	0

Soil Systemic Trials on Sunflower

Considerable publicity regarding the effectiveness of soil systemics, notably Furadan, for grasshopper, sunflower beetle and spotted sunflower stem weevil control developed in 1982 and 1983. In view of the unpredictability of most of these pests and the ease and low cost for control when they are present we were unsure this soil systemic "insurance" was worth the price. In addition, we can easily monitor (IPM methodology) for grasshopper and sunflower beetle. We rarely, if ever, see spotted sunflower beetle in our major Minnesota sunflower production area.

We had examined this concept in 1976-77 and found no yield benefit whatever. However, growers seemed to need additional information with which to make judgements about the concept.

We set out nine trials in Minnesota and North Dakota to compare soil systemics with foliars for, especially, defoliator control. Two trials are reported here (Tables 6 and 7). They were selected because of the uniformity of the sites upon which they were established and the uniformity of management by the grower. One, the Cote field, was high oil, and the other, the Flaskerud field, was low oil.

Neither field had economic defoliation from sunflower beetle in the untreated plots. There were significant differences in defoliation in each field however. Foliar sprays, even at very low dosages are significantly superior to soil systemics in reducing defoliation.

Spotted sunflower stem weevil was not present in either field. There are differences however in other stem infesting insects versus treatments. There were no differences in stem breakage so that was not reported. (Incidentally it is only stem breakage that reduces yield from stem insects.)

Table 6

SOIL SYSTEMIC TRIALS - MINNESOTA 1984
Red Lake County - Cote Field
David Noetzel - David Kabes

Treatment	Dosage in lbs ai/A	Average per cent defoliation	Average number tunnels/5 plant	Yield in lbs/A
Untreated	-	7.0	8.0	2176
Counter 15G (layby)	0.5	4.25	5.75	2081
Furadan 4F (foliar)	0.5	<1.0	6.25	2051
Furadan 15G (layby)	1.0	3.75	4.75	2024
Furadan 15G (layby)	0.5	2.75	3.75	2006
Pydrin (2.4E) (foliar)	0.01	<1.0	8.0	1984
Furadan 4F (Planting time)	0.5	<1.0	2.0	1944

Table 7

SOIL SYSTEMIC TRIALS ON SUNFLOWER - MINNESOTA 1984

East Polk County - Flaskerud Field

David Noetzel - Howard Person

Treatment	Dosage in lbs ai/A	Average per cent defoliation	Average number tunnels/5 plant	Yield in lbs/A
Pounce (32E) (foliar)	0.005	1.0	7.0	2255
Temik (15G) (layby)	0.5	7.25	10.5	2216
Counter (15G) (layby)	0.5	7.5	8.75	2170
Temik (15G) (layby)	0.25	8.0	8.75	2117
Untreated	-	7.0	10.0	2096
Furadan (4F) (foliar)	0.5	0.75	5.75	2047
Furadan (4F) (foliar)	0.125	1.0	7.5	1983
Furadan (15G) (layby)	0.5	7.0	10.5	1962
Baythroid (2E) (foliar)	0.0025	0.75	11.5	1961
Pydrin (2.4E) (foliar)	0.01	1.0	7.5	1927
Furadan (15G) (layby)	1.0	2.75	3.5	1882

We have not statistically analyzed the yields. It is unlikely there will be a statistical difference in yields from the Cote field. I am not sure that will be the case with the Flaskerud field.

We applied granulars at "layby" (2 to 4 leaf stage) for our comparisons. The plants without Furadan (ie. our plots) at planting were three or four days ahead of those treated with liquid Furadan at planting. We did not observe differences in bloom, etc. between planting time treatments and our plot area.

In Table 8 we have included average values of all soil treated Furadan plots and all untreated plots from our 1984 trials. We did not include planting time treatments by growers. As you can see yields were less from plots treated with Furadan (0.5 to 4 lbs ai/A) than when no treatment was applied. It is unlikely this difference is statistically significant.

To summarize we believe the insects one would use a soil systemic to control are either not present in economic numbers in Minnesota or if they (grasshoppers and sunflower beetle) are in economic numbers integrated pest management (ie. monitoring, etc.) provides by far the most effective, economical and safe control.

Table 8

SUMMARY OF ALL SOIL SYSTEMICALLY TREATED PLOTS VS. UNTREATED PLOTS MINNESOTA 1984

David M. Noetzel

Treatment	Dosage in lbs ai/A	Total Number plots (N)	Average yield in lbs/A
Furadan	0.5 - 4.0	80	1576
Untreated	-	120	1640

Sunflower Seed Insect Control

Banded sunflower moth has become a major pest of the Minnesota sunflower crop. Early surveys (1980-81) indicated it to be more important than seed weevil in west central Minnesota. In 1984, nearly every field in the state suffered some loss from this insect. 1984 plots at the Southwest Experiment Station (results not included) had 45% of the seeds infested. In Mahnomen and Norman counties (see Table 9) over 60% of the seeds show larval feeding. We also observed feeding which destroys developing florets leaving little evidence of damage. Thus we are speculating that total damage is higher than these data suggest.

We do not have a valid action level for determining when a field should be treated. We feel that if adult moths are readily visible along field margins it will usually be economically beneficial for the grower to treat. The presence of such adults, however, is rather transitory. Once a week visits to monitor can miss entirely the peak of adult flight. The peak of adult flight in the Mahnomen - Norman county area was between July 20-25, 1984. It was difficult to find adults toward the end of July in the same fields.

Observations and sampling in 1983 and again in 1984 suggest it is futile to treat field margins and expect any appreciable control of banded sunflower moth. Much of our earlier trials suggested timing of applications to the whole field based on sunflower phenology (ie. 10% bloom) to be successful. In 1984 we dissected heads a week or more prior to bloom and found hundreds of larvae in some of these plants. This evidence suggests earlier treatment may further improve control.

The need for insecticide applications for banded sunflower moth larval control were based on the observation of adult abundance around field margins. Timing of application was again related to the stage of bloom (eg. 1 to 3 plants in 10 with male florets open: equals 10-30% bloom) in the sunflower field. Results are reported in Tables 9 and 10.

The seed infestation in Norman County (Moen field) was nearly 100% banded sunflower moth larvae. The infestation in Wilkin County (Nordick field) was approximately 70% banded sunflower moth and 30% seed weevil.

Table 9

BANDED SUNFLOWER MOTH CONTROL - MINNESOTA 1984

Norman County - Moen Field

David Noetzel, Ken Pazdernik, Jim Martin

Treatment	Dosage in ai/A	Average number infested seeds/100 seeds	Yield in lbs/A
PP321	0.05	12.3	1743
SAN 415	2 pts.	16.3	1720
Penncap-M	0.5	20.3	1569
Lorsban	0.5	20.7	1742
SAN 415	1 pt.	22.7	1380
Furadan 4F	0.5	23.0	1532
SAN 415	4 pts.	23.3	1680
Larvin	0.5	24.0	1468
Pydrin	0.1	25.0	1398
Baythroid	0.05	26.7	1631
Supracide	0.5	27.0	1563
Dipel	2 pts.	28.0	1274
Pay-Off	0.05	29.0	1344
Ammo	0.05	30.7	1310
Furadan (field)	0.5	31.3	1454
Pounce	0.1	31.7	1399
Dipel	1 pt.	36.3	1285
Thiodan	0.5	36.7	1221
Dipel + ABG 6162A	1/2 + 1/2 pt.	37.0	965
ABG 6162A	1/2 pt.	45.7	886
Spur	0.05	49.0	1047
ABG 6162A	1 pt.	54.0	756
Pydrin (field)	0.12	55.7	767
Untreated	-	59.7	778
ABG 6162A	2 pts.	73.3	626
ABG 6162A	4 Pts.	59.7	465

Table 10

BANDED SUNFLOWER MOTH AND SEED WEEVIL CONTROL - MINNESOTA 1984

Wilkin County - Nordick Field

David Noetzel, Michelle Ricard

Treatment	Dosage in ai/A	Average number infested seeds/100 seeds	Yield in lbs/A
Ammo	0.05	3.7	1597
ABG 6162A	2 pts.	5.0	1652
PP321	0.05	6.0	1794
Baythroid	0.05	6.0	1575
Spur	0.05	7.3	1719
Penncap M	0.5	7.7	1458
Dipel	2 pts.	8.7	1436
ABG 6162A	4 pts.	9.0	1784
Thiodan	0.5	9.7	1636
ABG 6162A	1 pt.	12.7	1194
Furadan 4F	0.5	13.7	1429
ABG 6162A	1/2 pt.	15.0	1532
Supracide	0.5	16.0	1731
Pydrin	1.0	17.0	1388
Lorsban	0.5	19.0	1359
Dipel	1 pt.	19.0	1262
Larvin	0.5	19.3	1244
Pounce	0.1	21.0	1585
SAN 415	4 pts.	21.3	1451
SAN 415	1 pt	21.7	1204
Untreated	-	23.3	1419
SAN 415	2 pts.	29.3	1384
Pay-Off	0.05	31.3	1259
Dipel + ABG 6162A	1/2 + 1/2 pt.	33.0	962

We are obtaining something above 60% reduction of banded sunflower moth larval feeding damage in our tests. Probably significant differences in yield (from 400 to over 800 lbs/acre) were found in four sets of trials in 1984.

Among labelled compounds Lorsban, Furadan and parathion perform acceptably. It appears that several pyrethroids (PP321, Baythroid and Ammo-Cymbush) appear superior to the above three products but are not presently labeled.

Acknowledgements

The Department of Entomology would like to express special thanks to Dow, ICI, Mobay, Shell, Stauffer and Zoecon companies for Grants-in-Aid in support of this research.

In addition, we are most appreciative of grower cooperation in providing land, crop and insects for these trials. Of necessity we need to place plots where high insect populations exist. In many cases growers must apply controls and yet avoid our test site. Cooperating growers in the above trials include Hall Sundvahl, Norm Bosch, Les Hanson, Sanford Moen, Dale Cote, George Flaskerud and the Nordick family. Their help was absolutely essential for the excellence of the 1984 trials.

CEREAL CROPS

The leaf spot diseases, Tan Spot and Septoria Leaf Blotch were as common as usual this past season. In addition, we also found leaf rust in June on many of the early planted wheat fields. With the wet conditions it was expected that the rust might develop into a problem. Most of our public Spring wheat varieties have adult plant resistance, so finding rust on the young plants was not exceptional. As July dried-off and the adult plant resistance "took hold", the disease was stopped. However, there were some exceptions, with the very late planted wheat, which did have rust on it at harvest and with some private varieties that are leaf rust susceptible.

In general the barley crop showed the value of leaf spot resistance among the different varieties. The new varieties were only slightly affected with leaf spots this year.

Disease control practices to reduce or avoid crop loss start with using good seed, as disease-free as possible, treating the seed with a seed treatment fungicide to protect it while in the soil before growth begins. As many of the leaf spotting diseases are carried over from season to season on infected plant debris, the new crop should be planted on clean ground, preferably in a rotation system not following wheat or corn. If wheat must be planted on old wheat land, the plant debris should be buried.

During the early part of the growing season, the crop should be examined for stand and evaluated for potential yield. If sufficient fertility is available, the stand is good, and the growing conditions are favorable or expected to be favorable for producing a good crop then a grower should make a decision on whether or not to utilize the fungicide leaf spot control program. This practice will only reduce the crop loss that can occur from leaf spotting disease. Unfortunately, we do not have a system to evaluate the potential loss that may result from cereal diseases that can be applied before it is too late to make a chemical control application. Therefore, the use of this disease control practice will be based on potential yield, favorable growing conditions, past cropping experience with leaf disease and cultural practices.

In applying the fungicide to the crop it is most important that the applicator in the case of aerial application, does not use less than 5 gallons of water per acre. The application must start before heading, usually when the leaf spots do not appear to be of any consequence.

In some 1982 field trials, fungicide treatment resulted in 15% more yield than the untreated parts of the field. A grower - county agent demonstration, using a modified ground sprayer, resulted in almost 30% yield response.

In 1984 the results obtained from cereal leaf spot control varied by

area (environmental conditions) and to some extent by variety. In western Roseau county, near Roseau, 17.7% increase was obtained, in eastern Roseau county, near Greenbush, 7.8% increase resulted from fungicide treatment. In northwest Norman county yield increases were from 3% with Pioneer 2369 to 8.2% with Oslo. In Marshall county, near Warren, on minimum tillage a field of Wheaton had a 14.5% increase, and another field of Wheaton on plowed land had no increase, a third field of Wheaton on old potato land had an 8.3% increase with fungicide treatment. Over all yields in bushels per acre, were quite good, mostly in the high 70's to mid 80's.

Every year, observations of root rot, are reported. These below ground diseases are very difficult to evaluate because usually a complex of pathogens are involved. It has been reported that the Pythium fungus alone can account for a 15% crop loss. Knowing that there are several other fungi, which may affect the wheat plant root system we might summarize that a 20% reduction in yield annually is not uncommon. The use of systemic fungicides in experiments for the control of leaf spot diseases suggests that other fungi in the plant may also be affected. These other fungi might well be these root rot pathogens to which we are referring to reduce or minimize yield loss caused by root rotting fungi growers should practice at least 3 year rotation.

SUGAR BEETS

Cercospora leaf spot occurred on time again this year. However, due to the warm dry conditions in July, the disease moved very slowly.

In general, most fungicide treatments were economically beneficial to growers. Some growers expressed concern that the disease was not as severe as it was expected to be this year. However, one must remember that every grower, scout and fieldman and neighbor was out in the field looking for the first symptoms, and more important fungicide treatments were made on time, early, rather than late this year. With the dry July there should have been less disease. This is where the Cercospora leaf spot model would have provided growers with a decision making input regarding fungicide applications. This model should be available for growers, companies and consultants to use in 1985.

Disease control practices can and do work if no short-cuts are taken. Early detection is important, proper application is essential for chemical treatments to be beneficial. We have been extremely concerned about variety selection, fungicide selection and rightly so however, the application technique is just as important. Some aerial application of less than 5 gallons per acre were observed, giving less than adequate disease control. The general aerial and ground applications were successful in keeping the Cercospora leaf spot disease in check this year.

There has been some concern about phytoxicity with use of tin type

fungicides. Excessive use of the maximum rates, on 5-7 days intervals during hot humid days has caused necrosis leaf symptoms. At this time we do not have evidence of yield loss resulting from such effects. To prevent the occurrence of such symptoms, do not use the 20 ounce rate, tins do not have to be applied on 5-7 day intervals, unless the area is experiencing heavy rains. For best results follow the label directions.

If growers desire to tank mix fungicides they should be sure that the chemicals are physically compatible. There may be fungicide mixture on the market in 1985. However, I do not know why a grower should want to mix the protectant fungicides. The distribution of the MBC resistant isolates of Cercospora should indicate to growers that these fungicides are no longer dependable for disease control.

POTATOES

From a quality production point of view there are three areas of concern for potato growers, and those associated with this industry. Stand establishment, Verticillium wilt and harvest injury are affecting the profitability of growing a potato crop. Yes, growers have had such problems before. But were these problems as costly before?

Potato stand surveys this last year averaged 70.8% of what was thought to be in the field. This means that 29.2% (average) of the production cost was lost. Another way to appraise the situation one could have planted more carefully of course, 29.2% less acres and harvested the same crop. A reduction of $131.40 per acre production costs, if your per acre production is in the $450.00 per acre range.

About 15 years ago, the average potato stands were 68%. I am not sure that 70.8% is much of an improvement.

Stand loss occur from the following causes: seed piece decay and seedling diseases, sliver or eyeless seed pieces and mechanical miss spacing.

Seed piece decay and seedling blight (@ 10%) could be reduced by better quality seed, warming the seed before handling, planting in warm soil ($50^{o}F$) and not planting deep. The numbers at blind seed pieces could be reduced by doing a better job of seed cutting. Grading the seed tubers to size before cutting. Maybe a better seed cutter could be made. Larger seed pieces, 1 3/4 ounce, would help. As for the mechanical problems of planting, maintaining all of the seed picks, larger seed piece size, and depth adjustment according to soil conditions will help to reduce miss planting. One might even consider cup planter. Utilizing some extra help to make sure each cup was filled might be much cheaper than the potential loss of stand.

Verticillium wilt is no longer only a disease problem in our area, now

it is recognized as a nation-wide disease problem on potatoes.

In the simplest form, cleaning-up this disease problem is going to be expensive. The wilt fungus seems to do quite well living in the soil. However, the wilt fungus really makes its mark when one examines the infected plant debris. This may well be the important factor in the success of wilts rise to prominence in the potato disease world.

It is quite apparent that wilt got it start with the variety Kennebec. Very susceptible, sort of a "Typhoid-Mary" syndrome. The variety came on when Mercury seed treatment went out. It was widely grown especially as the processing industry developed. Crop rotation practices were changing, from potatoes one out of four years to once out of two years. Some growers even went to mono-culture. Also there were no restrictions for wilt on seed.

Verticillium reflects its presence by lowering yield quality. There may be total yield reduction, there is definitely tuber size (quality) reduction and internal vascular necrosis.

Can wilt be controlled? It would appear that many things can be done to reduce the losses resulting from wilt. Control will require a major effort by all parts of the industry.

In the field, the primary source of the disease, infected potato vines should be destroyed, after harvest. Crop rotation will have to be stretched out to 3 or 4 years, until such a time that the inoculum potential in the field has been reduced. Disease resistant varieties will have to be worked into the system. Seed stocks will have to be cleaned up. Last but not least, ultra susceptible varieties should not be grown.

Soil fumigation can reduce the crop loss caused by Verticillium wilt. Even though the results of soil fumigation are economical, It does not appear that fumigation alone will solve the problem. The inoculum going back into the soil from infected stems must be eliminated. Then we should find much better results from soil fumigation.

Wilt resistance has been identified in the Minnesota Potato Breeding materials. As this material becomes a new variety, the grower will have to still exercise disease control practices to reduce the amount of disease inoculum or these varieties will also succumb to the disease.

The 1985 fall season was somewhat deleterious to our potato harvest quality. The hot weather and dry soil condition resulted in a good year for tuber bruising. Once in the bin it was difficult to cool the crop. Many potatoes were dug at 85^{o}F air temperature. Because of soil clods, a lot of bruising occurred. Again the solution to these problems rest with the grower. Frequent checking for tuber injury during digging operations, machinery adjustment as needed when conditions change.

SUNFLOWERS

Mildew, much more prevalent this year. Some fields were observed with 20% infected plants. The soil can become contaminated from infected debris, so flowers should not be grown on old flower land. Growers should not use seed from infected crop for planting next year's crop. Grow resistant varieties where available.

White mold continues to take its toll. This disease should be of real concern to flower growers. The fungus, in the form of sclerotia, go back into the soil during harvesting. These dark colored, hard fungal bodies about the size of a pencil eraser, many remain viable in the soil for many years. Not only is the flower crop susceptible, but all broad leaf plants are susceptible: soybeans, edible dry beans, potatoes, etc.

White mold can infect the flower plant through the roots, stem injury and head. At present, the best practice to follow is a long rotation system.

FUNGICIDES[1] FOR USE ON FIELD CROPS
CEREALS
SEED TREATMENT - WHEAT, BARLEY, AND OATS

COMMON NAME	TRADE NAMES	BUNT CONTROL	SEEDLING BLIGHT CONTROL	REMARKS
Captan	Captan Orthocide Evershield (Several other names)		G**	Combination with maneb or zineb for bunt.
Captan-HCB	Ortho seed protectant	G	G	
Carboxin	Vitavax			For control of loose smut
Carboxin & Thiram	Vitavax 200	F	F	For bunt, seedling blight and loose smut control.
Maneb	ABSCO DB Green ABSCO DB Yellow cover-up Granol NM	F	G	DB Green & Granol NM are combined with Lindane
Maneb	Granox NM	G	G	
PCNB	Terra-coat Terra-coat	G G	F F	Combined with Terrozole Combined with Terrozole
Polyram		F	G	
TCMTB	Busan (cover-up L)	G	F	
Thiram	Arasan-75 Evershield Thiram	F F	G G	

* Seed injury may occur if high moisture seed is treated and stored.

** F = Control Fair
G = Control Good

1/ There may be other seed treatment fungicides on the market that I am not aware of that are also satisfactory for treating cereal seed.

(CONTINUED) **FUNGICIDES[1] FOR USE ON FIELD CROPS**

CEREALS

Cereal Leaf Diseases		Remarks
Dithane M-45 Manzate 200 Maneb Zineb Kocide 101 Bayleton	Rusts and Leaf Spots	Apply by air, using minimum of 5 gallons of water per acre, and spread-sticker per label. See label rate and limitations.
Tilt	Rusts (leaf, stems, stripe) and mildew.	Used by growers only with experimental use permits. Treated grain can be marketed.

POTATOES

Seed Piece Treatment

Captan
Orthocide Plus
(Captan + Mertect)
Maneb
Polyram
Zineb
Dust Treat
(Zineb + Streptomycin)

Late Blight and Early Blight

Bravo
Copper
Kocide 101
Difolatan
Duter (no spreader sticker)
Mancozeb
Dithane M-45
Manzate 200
Maneb
Dithane M-22
Manzate
Zineb
Polyram

See label for rates and limitations

POTATOES (continued)

Late Blight and Early Blight (continued)

Blight Out (Polyram + Maneb)	
Ridomil MZ	A steroid type systemic fungicide especially good for Late Blight, maneb is added for Early Blight protection. Use as needed, Late Blight has been able to develop resistance when excessive applications have been made.

SUGAR BEETS

Seed Treatment

See Label for Rates & Precautionary Instructions		For Control of Damping-Off				Remarks
		Aphanomyces	Pythium	Phoma	Rhizoctonia	
Captan 35.2%	Slurry	-	-	-	-	General Seed Treatment
Demosan 65W	Slurry	-	G	-	G	May be used as a supplemental treatment
Lesan	Slurry	E	E	P	P	May need 6 oz. on high

NOTE: For maximum protection use with a fungicide that controls Rhizoctonia & Phoma.
CAUTION: See label for care in handling.

Maneb 80% Dithane	drillbox	-	G	-	G	
Maneb + Zinc 80% Dithane M-22 Special	drillbox	-	G	-	G	
PCNB + Etirdiazole Terra-coat 1-205	liquid or slurry	G	G	F	E	
Terra-coat SD-205	slurry	G	G	F	E	
Thiram Arasan 50 Red	drillbox or Dust	-	-	G	G	
Arasan 50 Red ND	Dust	-	-	G	G	

P = Poor, F = Fair, G = Good, E = Excellent, - = No Data.

Cercospora Leaf Spot

Control requires - early irregular applications, at recommended rates.

Copper	Remarks
CITCOP 4E	
CITCOP 6E	
Copper County - N	
Kocide 101	
Kocide 404	
Oxy-Cop 8L	
Tribasic Copper Sulfate	For all fungicides used see label for rate and limitations. Do not use less than minimum rate, during favorable conditions of infection the spray schedule may be closed-up. When leaves are wet for 8 1/2 continuous hours, temperatures above 62° (optimum 75°) conditions are favorable for infection.
Mancozeb	
Dithane M-45	
Dithane M-45 Flowable	
Manzate-200	
Maneb	
Dithane M-22	
Maneb	
Metiram	
Polyram	
Metiram + Maneb	
Blite-Out	
Triphenyl Tin	
Hydroxide	
Duter	20 ounce rate, at 5-7 day intervals, during hot, humid days, may result in some leaf injury. Follow schedule on the label.
Super Tin	
Triple Tin	

Powdery Mildew

Fungicides for Powdery Mildew Control	Remarks
Benomyl Benlate	
Sulfur *BIG 8 that is Flowable 64% Magnetic 6 Flowable 51% That flowable 52% TOP-COP + Sulfur	Apply sulfur if mildew appears by mid-August. One Application usually gives adequate protection for 4 weeks.
Copper	
See listing under Cercospora leaf spot	See label for rate and limitations. *Can be used in irrigation system.

Rhizoctonia and Scab

PCNB - Terraclor emulsifiable concentrate
(Broadcast or in-furrow applications)
See label for rates and limitations.

EFFECT OF RONILAN, BENLATE AND MERTECT 340-F ON THE CONTROL OF WHITE MOLD IN PINTO BEANS

Pinto bean growers have recognized for a long time that White Mold, caused by Sclerotinia sclerotiorum can be especially detrimental to pinto bean yields. Chemicals such as Benlate have been important tools in the control of White Mold epidemics. The following study was designed to evaluate the effectiveness of different rates and formulations and timing of Ronilan and Mertect as compared to the label rate of Benlate.

The Ronilan and Benlate treatments were successful in controlling White Mold, as noted by the percentage of wilted canopy and the resulting plot yields (Table 1). The plot treated with Ronilan WP and Benlate had the highest yields. The plots treated with Ronilan Fl, on the average, did not yield as high as the ones treated with Ronilan WP or Benlate. Mertect 340-F at either rate was the least effective against controlling White Mold.

The data collected in this experiment indicates that Benlate, when properly applied, still has the ability to control White Mold in Minnesota. Ronilan, when the Federal label is obtained should also be a treatment of choice. Competitive price and availability along with effectiveness will be the factors which will keep our chemical tools a viable option in the fight against White Mold.

Chemical control, however, is just one method of keeping White Mold under control. Three year rotations with non-host crops such as corn and small grains will do a lot to prevent serious build-up of White Mold in the soil. Crops like sunflowers, which are very susceptible to White Mold, should be avoided in a dry bean rotation. Planting tolerant varieties such as Bonsi (Ex Rico 23) Neptune + C-20 navies is another way to help keep the disease to a minimum. When selecting other classes of Dry beans, select varieties with upright growth habits which will encourage good air circulation in the canopy.

When considering when to spray, remember that fields which have been wet for a long extended time before blossoming are good candidates for White Mold infection. The odds for White Mold greatly increase when bean foliage covers the row. When these conditions are present, and the farm has a White Mold history and the outlook is for continued damp weather the present recommended sprays are Benlate and Topsin M at 1.5 - 2 lbs/acre at about 100% bloom. Spraying a second time has show to reduce the disease but may not be economically feasible.

White Mold spray program will not control 100% of the disease but in most cases should be cost effective. Coverage is very important. Since these chemicals are systemic and only travel upward in the plant it is important to get adequate canopy penetration. Ground sprayers with more than 1 nozzle/row and high pressure (20-40 gal H_2O, 75-125 lbs.) will give

the most consistent results.

Predictive programs for White Mold development have been worked out in New York and Michigan. The New York model is 90% correct in telling growers not to spray and 45-50% correct when telling growers to spray. We will be watching these programs as they develop and be trying them experimentally in Minnesota as they develop further.

TABLE 1. White Mold Control Trial - Yields, White Mold Levels and Anthracnose Levels

Treatments					White Mold Levels			
	First Application	Second Application	Yield (lb./A)		8/13 % Wilted Canopy		8/22	
Ronilan WP (.075 lb ai/A)	70% bloom	10 days later	2581	a	0	a	2	a
Ronilan WP (0.75 lb ai/A)	peak bloom	11 days later	2364	ab	2	a	12	ab
Benlate (2 lb prod./A)	70% bloom	10 days later (peak bloom)	2364	ab	3	a	15	abc
Ronilan WP (1.0 lb ai/A)	70% bloom	10 days later	2362	ab	0	a	0	a
Ronilan Fl (1.0 lb ai/A)	70% bloom	10 days later	2323	abc	0	a	1	a
Ronilan WP (1.0 lb ai/A)	peak bloom	11 days later	2229	abc	3	a	8	a
Ronilan Fl (0.75 lb ai/A)	70% bloom	10 days later	2193	abcd	0	a	10	a
Ronilan Fl (0.75 lb ai/A)	peak bloom	11 days later	2035	abcd	5	ab	27	bcd
Ronilan Fl (1.0 lb ai/A)	peak bloom	11 days later	1932	abcd	9	ab	30	bcd
Mertect 340-F (32 Fl oz/A)	70% bloom	10 days later (peak bloom)	1786	bcd	21	c	38	d
Mertect 340-F (16 Fl oz/A)	70% bloom	10 days later (peak bloom)	1665	cd	10	abc	37	cd
Unsprayed Check			1529	d	16	bc	42	d
LSD .05 =			650.5		11.1		21.8	

CHEMICALS FOR DISEASE CONTROL IN DRY EDIBLE BEANS

Chemicals are an important tool in controlling the diseases of dry edible beans. A list of the names of a number of chemicals which are effective in controlling some of the most common diseases are listed below.

The diseases caused by fungi are more easily controlled by chemicals than the bacterial blights. Common bacterial blight, a seedborne bacterial disease, is not efficiently controlled by chemicals. There is evidence, however, that coppers will slow down halo blight (seedborne) and brown spot.

Coverage, timing and application rate is very important when applying chemicals. Ground applications should be made with 30-50 gallons of water with 75-125 lbs. pressure. Air applications should be made with no less than 5 gallons/acre.

Many chemical applications have failed because of inadequate coverage, (due to low rates, low pressure or flying too high, etc.). Coverage is especially important with systemics like Benlate and Topsin-M which are restricted to upward movement in the plant. Good canopy penetration is necessary for optimum control using these chemicals. Though coverage is also important for protectant fungicides.

This list contains information which is current but subject to change. To assure appropriate use, **READ THE LABEL** before use, and follow the recommended rates and safety precautions.

Dry Beans

Chemicals Labeled for Seed Treatment of Fungus and Bacterial Diseases

SEED TREATMENT

Chemical	Labeled Use	Rate	Company
Agri-Strep 500	halo blight	50,000 ppm (5%) -83 lb./100 gal. spray or slurry	Merck & Co. Inc.
Agrox 2-way	damping off, seed decay, seedling blight	2 oz./bu. mixed thoroughly with seed in planter box	Chipman Chemicals, Inc.

Chemical	Labeled Use	Rate	Company
Agrox 3-way	damping off, seed decay, seedling blight	3 oz./bu. mixed thoroughly with seed in planter box	Chipman Chemicals, Inc.
Agrox D-LPlus	seedling blight, damping off, seed decay	2 oz./bu./ mixed thoroughly with seed in planter box	Chipman Chemicals, Inc.
Captan 400	seed decay, damping off, seedling blight	2 to 3 fl. oz. /100 lb.	Gustafson
Hopkins-Bean Seed Treatment	damping off, seedling blight; for use in Michigan, Nebraska, New York, North Dakota, and Wisconsin states only	3 oz./bu./ mixed thoroughly with seed in planter box	Hopkins
Lesan-70-WP	damping off, seed rot	1 oz./100 lb. seed	Mobay

Dry Beans

Chemicals Labeled for Foliar Spray of Fungus and Bacterial Diseases

FOLIAR SPRAY

Chemical	Labeled Use	Rate	Company
<u>Benomyl</u>			
Benlate	white mold, grey mold	1.5 to 2 lbs./A at 25%-50% bloom; repeat at peak bloom 14 day PHI.	DuPont
<u>chlorothalonil</u>			
Bravo 500	rust,	2 to 3 pt./A at	SDS Biotech

Chemical	Labeled Use	Rate	Company
	anthracnose, downy mildew	early bloom; repeat at 7 to 10 day intervals. 6 week PHI.	
copper			
Citcop 5E	bacterial blights	3 pt. in 3 gal. water/A. beginning when weather conditions favor disease development and continue at 7 to 10 day intervals to harvest.	Tennessee Chemical Company
Tri-Basic Copper Sulfate	angular leaf spot anthracnose bacterial blight, downy mildew	2 to 4 lb./A. beginning when plants are about 5 inches tall and repeat every 5 to 7 days.	Tennessee Chemical Company
Flowable Tri-Basic Copper	bacterial blights	1 to 2 qt./A. beginning when disease is first expected and repeat at 7 to 10 day intervals.	Tennessee Chemical Company
Kocide 101	halo blight and common blight	1 to 3 lb./A. beginning when plants are 6 inches high and repeat at 7 to 14 day intervals.	Kocide Chemical Corporation
Kocide 606	halo blight and common blight	1 1/3 to 4 pt./A. when plants are 6 inches high and and repeat at 7 to 14 day intervals.	Kocide Chemical Corporation
copper & sulfur			
Kocide 404S	halo blight and common blight rust.	1 to 3 qt./A. when plants are 6 inches High and repeat at	Kocide Chemical Company

Chemical	Labeled Use	Rate	Company
	NOTE: the first rate is for control of blights the second is for control of rust.	7 to 14 day intervals 1.5 to 3.0 qt./A. make 3-4 applications at 7-10 day intervals.	
Top Cop FL	mildew, rust, halo blight	2 qt./A. beginning during early bloom or when disease first appears.	Stoller Chemical Corporation
dichlone			
Dichlone 50-WP	anthracnose	1.0 to 1.5 lb. /100 gal. water. Use 100 to 150 gal. of spray/A. weekly intervals in a series of 4-5 applications, starting just before bloom.	FMC
maneb			
Maneb 80	anthracnose, rust	1.9 lb/A. beginning during early bloom or when disease first appears, then at 4 to 7 day intervals as needed.	Pennwalt Corporation
maneb + zinc			
Agsco MN Flowable	anthracnose, downy mildew, rust	0.8 to 2.4 qt./A. when disease first appears then repeat at 5 to 7 day intervals.	Agsco, Inc.
Dithane FZ	anthracnose, downy mildew, rust	0.8 to 2.4 qt./A. when disease first appears and repeat at 10 day intervals as long as necessary.	Rohm & Haas

Chemical	Labeled Use	Rate	Company
Dithane M-22 special	downy mildew and rust	1 to 3 lb./A. when disease first appears and repeat at 7 day intervals.	Rohm & Haas
Manex	anthracnose, downy mildew, rust	1.2 to 1.6 qt./A. 100 gal. spray/A. beginning when plants are small. Repeat at 5 to 7 day intervals.	Griffin Corporation
Manzate D	rust	1.5 to 2.0 lb./A. when disease first appears and repeat at 7 day intervals as needed	DuPont
Manzate FL-4	anthracnose, downy mildew, rust	1.2 to 1.6 qt./A. when disease first appears and repeat at 4 to 10 day intervals (7 day intervals for rust)	DuPont
sulfur			
Kolospray	powdery mildew, leaf spot, rust	4 to 7 lb./100 gal./A. when first tree leaves form or at first sign of disease. Repeat at 7 to 10 day intervals.	DuPont
thiophamate methyl			
Topsin M-4.5 F	white and grey mold	30 to 40 fl. oz./A. once at 50% to 70% bloom or 20 to 30 fl. oz./A. twice first application at 10 to 30% bloom and second application 4 to 7 days later or at peak bloom.	Pennwalt

Chemical	Labeled Use	Rate	Company
zineb			
Dithane Z-78	anthracnose, downy mildew rust	3 to 4 lbs./A. when first blossoms appear and repeat at 7 to 14 day intervals to within 7 days of harvest.	Rohm & Haas
Zineb 75-WP	rust anthracnose	1.5 to 2 lb./100 gal. of water use 100 to 125 gal. of spray/A beginning when disease first appears and repeat at 4 to 7 day intervals as long as disease threatens.	FMC
ziram			
Ziram W-76	rust, anthracnose	1.5 to 2 lb./100 gal./A. when disease first appears and repeat at 4 to 7 day intervals.	Pennwalt
Ziram F-4	rust, anthracnose	2 pt./100 gal./A when disease first appears and repeat at 4 to 7 day intervals.	Pennwalt

CORN NEMATODES - 1984

The dominant corn parasitic nematode of southern Minnesota is the lesion nematode, Pratylenchus hexincisus. This nematode is not distributed evenly across fields and locations where high numbers are present are infrequent. Results of the late 70's show that measurable losses in heavy soils do not occur if stress is absent and growing conditions are nearly ideal, however, losses in study sites averaged 6%. In sandy soils yield reductions averaged about 10%. Recently the lance nematode, Hoplolaimus sp. was found in abundance in a corn field near Red Wing. Yield effects in 1983 were hard to measure due to extensive corn borer damage. In 1984, little difference in plant height, yield and lance nematode number was recorded in plots with less than 135 nematodes/soil sample (116 cm^3) when soil was sampled in May. Larger yield reductions and plant size effects were found when nematode numbers were greater than 148/soil sample and if nematode numbers were higher than 250 little treatment differences existed. The lance nematode is larger than the lesion and is thought to be more damaging therefore at lower numbers.

Nematodes do exist in Minnesota fields and can be at populations that will reduce yields. However. yield reduction seems to be dependent on stress factors unless nematode population is very high. Factors that contribute to stress are unclear but soil type, moisture supply, plant population and hybrid appear to be important. Since nematodes are present in Minnesota and can be shown to reduce yields it seems likely that other problem areas may be related to nematode levels and stress factors.

CORN SAPROPHYTIC LEAF MOLDS AND EAR ROTS

This fall many farmers commented about an unusual amount of black material on the corn combine. In some fields, the mold growth was so heavy that black clouds of "dust", really fungal spores, billowed up behind combines as they moved through fields. Machines were reported to be covered with black sooty dust and some reported headaches, running noses and eye irritation, i.e. an allergic effect. This black material was not a new problem in terms of the fungi present on corn plants in the fall, but more unusual in the amount of fungal growth and sporulation at the time of harvest. Some fields did have areas with high levels of common smut, which can produce a fair amount of black powdery material but this was not the source of black dust that was so wide spread.

The high level of saprophytic molds on corn plants at harvest was the result of several environmental factors. First, large amounts of green corn tissue was killed in the hard frost of September 26. Leaves, husks and even stalk tissue was suddenly killed rather than slowly drying and dying as is normal. This killing frost provided large quantities of suitable tissue for saprophytic colonization. Second, all this recently killed green tissue was then provided with a period of warm, humid even wet weather which is ideal for growth and development of the "normal" saprophytic molds. The result was rapid, complete and nearly total colonization of corn plant tissue by fungi such as Torula, Cladosporium and Alternaria. These and other dark spore saprophytic molds are always present but usually not in such a large number at one time. Third, the lack of strong winds and washing rain storms in October allowed this high spore population to remain on the corn tissue longer than expected. The fungi found on corn plants in October cause no known feeding problems with the grain or silage. In fact, they are a normal component of that material only the volume may have increased in 1984. Clearly sneezing and/or coughing was increased, i.e. dust problems and some people may be allergic to the load of fungal spores. A simple solution was the use of appropriate dust masks when harvesting.

Ear rots or molds are usually only minor problems in Minnesota corn production fields, however, the fall of 1984 which produced the "Black Combine Symptom" was also ideal for development of ear molds. Ear rot is infrequent but not impossible in Minnesota. Ear rot development is favored by slow drying conditions at harvest and the use of hybrids with tight husks that further slow field drying. Gibberella ear rot, tip rot has pink or white mycelium that is not powdery between and on kernels and the husk adheres tightly. Give careful attention to proper drying and storage of corn in 1984.

SOYBEAN DOWNY MILDEW

This soybean disease was observed in several Minnesota fields in 1984 especially in the northwest, where soybean production is expanding rapidly. While it was new and quite dramatic in fields from Mahnomen to Marshall this disease has been observed in Minnesota every year to some extent since 1981. Overall severity was judged to be low in all years. Downy mildew appears as pale green to light yellow spots that become bright yellow lesions of indefinite size and shape. Gray mycelium and spores of the fungus Peronospora manchuria can be seen especially if moisture is present on the lower leaf surface. During periods of high humidity and temperature in the range of 65-75°F sporulation is favored and the resultant infections may be so numerous as to nearly cover the leaf with many small yellow green lesions. The leaves near the top of the canopy in late August are often severely infected and turn yellow, brown, curl and drop prematurely.

Pod infection may result without evident external symptoms. However, the interior of the pod and the seed coat become covered with white mycelia and reproductive structures called oospores. The seed will appear to be covered with white encrusted material. Seed infected without this covering present often has cracks in the seed coat and may be smaller or lighter in weight. Yield reduction upto 8% is reported but not documented in Minnesota. Although there are many races of the downy mildew fungus identified, resistance still performs satisfactory.

This fungus overwinters as oospores in infected plant material - leaves and on seeds. Seedlings may be infected, probably in the hypocotyl from oospores on the seed coat or from leaf residue. Hyphae grow through the plant and out into the first several leaves. These systemically infected plants are stunted and may be covered with mildew growth which provides the inoculum for further spread. Sporulation on systemically infected plants and in local lesions occurs between 50 - 76°F when humidity is high. The conidia produced are spread by air currents and germinate in 12 hrs. At germination a hyphal tube (mycelium) may enter the plant directly via a stoma or penetrate via a specialized structure. The mesophyll area is colonized first and then the palisade layer. Resistant soybean lines stop hyphal development quickly and little colonization results. Susceptible lines at infection produce angular lesions. Leaf age affects infection, 8 days old leaves and older are resistant while 5 or 6 day old leaves are susceptible. High temperatures increases leaf resistance to downy mildew or may increase leaf age.

Resistance is expected to provide control of downy mildew. Seed treatment will reduce seedling infection and is recommended if seed lot is known to be infected. Planting soybeans on soybean land is not recommended as this would favor this disease. A one year rotation without soybeans and incorporating soybean residue is also a recommended control measure.

A greenhouse experiment and field test at Rosemount plant pathology farm was done to determine the effect of downy mildew on seedlings and plant yield. A soybean seed lot identified by Minnesota Crop Improvement and tested by the Department of Plant Pathology, University of Minnesota was determined to have 4% encrusted seed at harvest in 1982. Seed from this lot was used in 1) a greenhouse germination study with two seed treatments and 2) a field seed treatment/yield study at the Rosemount farm.

Soybean emergence and downy mildew disease severity readings are reported in Table 1. Emergence rates were higher with treated seed than untreated seed (% of # seed planted) and less leaf disease was recorded when seed treatments were used. The field study used the downy mildew seed lot and another seed lot without any history of the disease in a yield trial. Stand counts were recorded 16 days after planting and at 41 days. Harvest yields were determined from two rows 10 feet long. Seed treatment benefits were recorded for stand with both seed lots while yield increases were consistently greater only when the diseased seed lot was used (Table 2).

TABLE 1. Soybean emergence and downy mildew incidence affected by seed treatments.

	Seed Treatments		
% Emergence	**Apron**	**Captan**	**Check**
80°F			
8 days	90	85	79
13 days	90	93	84
70°F			
13 days	86	87	79
% Leaf Area Diseased			
Cotyledon	0.8	0.3	13.5
Unifoliate	0.6	0.3	6.7
1st Trifoliate	0.3	0.4	8.5
Whole plant at:			
14 days	0.3	0.3	9.6

TABLE 2. Stand and yield for two soybean seed lots after seed treatment.

Treatments	Stand (Plants/Ft.)		Yield
	5/27	6/21	B/A
Seed without Downy Mildew			
Plus Apron 25W	5.2	6.5	37.6
Plus Vitavax 200	5.1	6.2	37.6
Plus Captan	4.2	6.4	40.5
Plus Demosan	4.2	5.9	37.4
Plus Thiram	4.8	6.5	38.8
Plus PCNB	4.8	6.2	38.7
No Treatment	4.3	5.8	39.0
Seed with Downy Mildew			
Plus Apron 25	5.3	7.1	36.7
Plus Vitavax 200	4.2	6.2	40.0
Plus Captan	5.3	6.2	37.6
Plus Demosan	5.8	6.8	38.4
Plus Thiram	4.8	6.3	39.2
Plus PCNB	4.9	6.5	38.6
No Treatment	4.5	5.7	34.4

SOYBEAN SEED TREATMENT - 1984

Soybean seed treatments using the following products (Vitavax 200, Vitavax 34, Apron, Thiram 42S, Captan) were applied to three seed varieties (Corsoy 79, Simpson and McCall) of two grades (Certified and Bin Run) at these locations (Crookston , Morris, Lamberton, Waseca, Staples, Rosemount and West Concord). Stand counts and yields were determined at all locations but Morris. No observations are reported for Morris due to a herbicide problem. Germination tests were run, both the regular germination test and the cold/stress test at the St. Paul Campus. The seed quality used in 1984 was excellent. No differences were recorded for Certified and Bin Run seed of the three seed varieties used. Cold test germination values were similar to regular test results with all seed varieties. Seed was purchased from the Crookston, Morris and Waseca areas. All seed treatments were applied at label rates at St. Paul.

TABLE 1. GERMINATION TEST RESULTS - SEED SOURCE

	% Germination	
	Regular Test	Cold Test
McCall		
Certified	97.1	99.0
Bin Run	99.0	97.0
Simpson		
Certified	97.7	95.0
Bin Run	95.7	95.0
Corsoy 79		
Certified	96.7	97.1
Bin Run	97.3	97.4
Grand Mean	97.3	96.8

TABLE 2. YIELD RESULTS WHEN USING TREATED SEED

	YIELD AND BUSHELS		
	Simpson	McCall	Corsoy 79
Vitavax 200 + Apron	43.4	36.8	38.5
Vitavax 200	44.0	34.5	38.4
Vitavax 34	43.7	34.6	38.9
Thiram 42S	42.7	35.7	38.5
Apron	44.4	38.1	37.9
Captan	41.5	37.9	37.8
None (Check)	43.0	37.2	37.5

The Minnesota seed quality and ability to germinate under Minnesota conditions is usually good to excellent. Little difference in yield and/or stand was observed in these tests. The highest yield for McCall, susceptible to Phytophthora was with Apron seed treatment and Simpson, resistant to race 1 + 2 also yielded highest when treated with Apron only. Corsoy did not show this response but is multi race resistant and has moderate tolerance to Phytophthora. General seed treatments are not normally suggested for soybean seed, however, fungi can invade soybean seed before harvest, after harvest in storage and following planting which may result in lower stand populations or weaker plants. The above results were from sites not known to have serious Phytophthora disease. Data from sites known to have severe Phytophthora indicate benefit from Apron seed treatment. This response was not seen with all soybean varieties.

TABLE 3

PHYTOPHTHORA RESISTANCE/TOLERANCE/TREATMENT

Soybean Rating			Stand		Height	Yield
Race	Tolerance		Early	Late	cm	Bushel
S	5*	HDT	4.6	0.8	47	9.9
		HDNT	3.9	0.3	40	4.6
		LDT	6.0	4.4	42	25.1
		LDNT	5.3	3.6	41	19.3
R	5	HDT	5.6	0.4	44	4.8
1 & 2		HDNT	5.5	0.1	41	2.3
		LDT	8.0	2.4	42	19.2
		LDNT	7.1	4.8	39	18.5

TABLE 3 (continued)

PHYTOPHTHORA RESISTANCE/TOLERANCE/TREATMENT

Soybean Rating			Stand		Height	Yield
Race	Tolerance		Early	Late	cm	Bushel
S	3.5	HDT	6.1	6.5	71	36.9
		HDNT	6.1	4.3	62	28.9
		LDT	7.6	7.4	62	35.0
		LDNT	7.0	7.1	56	31.5
R	3.8	HDT	6.8	5.9	70	37.5
1 & 2		HDNT	6.8	5.5	65	32.1
		LDT	7.5	8.4	56	35.6
		LDNT	7.5	8.3	52	31.0
S	3.4	HDT	6.6	6.0	61	38.8
		HDNT	6.3	5.9	58	38.8
		LDT	6.8	7.5	57	33.4
		LDNT	6.9	7.6	50	33.0
R	3.5	HDT	6.5	6.4	79	36.7
1,2,3,6,		HDNT	6.0	6.1	71	37.8
7,8,9		LDT	7.5	7.1	67	33.9
		LDNT	7.4	6.4	57	33.1

Race, S = susceptible, R = resistant to known races

Tolerance Number. Range 1-5. 1 = No dead or stunted plants. 5 = Most plants dead and stunted. * = Estimated.

HD = High Disease
LD = Low Disease
T = Apron on Seed
NT = No Seed Treatment

CORN EYESPOT CONTROL

Since this disease is found in a wide area of Minnesota two studies were conducted to control this disease. One location was in an experimental plot at Staples - irrigated and the second in a production field (Morrison County) - dryland. The previous crop at Staples was corn and the Morrison site had corn for seven years. Several fungicides were applied at Staples and one at the Morrison location.

Corn produced under irrigated conditions in north central Minnesota is often damaged by eyespot. The Staples corn study site had eyespot and was left unplowed in the fall of 1983. Spring soil preparation was kept to a minimum and corn, Pioneer 3978 was planted May 11 into the corn debris. This represented a corn on corn minimum tillage production operation. No disease inoculation was attempted, all disease development was the result of natural infection. Corn disease observations were made in the center two rows (30") and harvest yields determined from 10 foot sections of the center rows. Fungicides were applied on June 29 (corn at 18"), July 14 and 28. The boom covered four rows (10 ft.) and delivered 60 gal/A at 180 PSI. Disease development was slow, steady and typical of the previous two years. The plot was harvested by hand on October 4 and yields are calculated for 15.5% moisture.

The Morrison County site was treated on July 17 with Tilt at 50 gms ai/A. The plants at treatment were nearing tassel and eyespot was present. The plants were observed on August 1 and disease level had not increased over that seen on July 17. Disease ratings were made on August 24 and the plot was hand harvested October 10. Yields are calculated for 15.5% moisture. The disease was well established when sprayed and while less disease developed on treated plants, yields were only slightly better.

TABLE 1. EYESPOT CONTROL WITH FUNGICIDES AT STAPLES

Treatments and Dates Applied	Yield - Bu/A
Mertect 340F 16 Fl. oz.	
6/29	150.4
6/29 + 7/14	168.0
6/29 + 7/28	154.0
Dithane M-45 2 lbs.	
6/29	156.3
6/29 + 7/14	154.3

TABLE 1. (continued) EYESPOT CONTROL WITH FUNGICIDES AT STAPLES

Treatments and Dates Applied	Yield - Bu/A
Dithane + Mertect 2 lbs. + 8 Fl. oz.	
6/29 + 7/14	165.8
R + H 3866 6/29	
0.06 lbs. ai.	160.2
0.12 lbs. ai.	164.2
Tilt 50 gms. ai.	
6/29 + 7/14	170.8
6/29 + 7/28	179.6
Check	
No Spray	156.4

TABLE 2. EYESPOT CONTROL IN MORRISON COUNTY

JOHN VAN WIENEN FIELD - KEN OLSON EXTENSION AGENT

	Eyespot Numbers - 8/24		Yield
	Ear Leaf	2nd Leaf Below	Bu/A
Treated	95	57	153.4
Not Treated	158	980	149.9

1/85 AGRICULTURAL EXTENSION SERVICE PW-18
UNIVERSITY OF MINNESOTA - U.S. DEPARTMENT OF AGRICULTURE (revised)
INSTITUTE OF AGRICULTURE, FORESTRY AND HOME ECONOMICS
ST. PAUL, MINNESOTA 55108

Weed and Brush Control Along Roadside, Drainage Ditches, and Other Rights-of-Way

Richard Behrens, Extension Agronomist

Weeds and brush along roadsides and rights-of-way must be controlled to protect the large investment in these public utilities and to protect the public who use them. If not controlled, weeds and brush create hazards by restricting visibility at road intersections and on highway warning and marker signs. Brush interferes with telephone and electric power lines. Weeds fill in drainageways and are fire hazards around buildings. Roadsides and rights-of-way are "weed nurseries" which propagate troublesome weeds that then spread to adjoining cropland. In addition, poisonous plants, such as poison ivy, and pollen-bearing plants, such as ragweed, are public health hazards. Noxious weeds and brush in rights-of-way areas must be controlled, but complete vegetation control is usually not desired because of erosion and aesthetic considerations. Periodic applications of 2,4-D or one of the related phenoxy herbicides, or combinations of these, will control most of the troublesome broadleaf weeds and brush without killing the grasses and most of the desireable native broadleafs (forbs). "Spot treatment", or spraying only where patches of noxious weeds and brush occur, is recommended. Grasses and forbs will be favored by the lack of broadleaf competition. Encouragement of the grasses and forbs in these areas provides erosion control and wildlife cover and also improves the appearance of the roadway. Grasses are fibrous rooted and hold the soil better on steep slopes than the tap-rooted broadleaf weeds. Also, most grasses do not grow as tall as broadleaf weeds or brush and require less mowing along roadside shoulders to maintain proper visibility and to minimize excessive drifting of snow onto roadways.

Methods of Weed and Brush Control

Weeds and small brush can be controlled by periodic mowing. However, two or more mowings are often required to keep weeds down and to prevent weed seed formation. When brush is mowed or cut it quickly resprouts from the base, and becomes thicker. Frequent cutting is necessary for control. With high costs of labor, fuel and machine repairs, mowing of highways and other rights-of-way is extremely expensive. Also, early mowing, before weed seeds mature, is a hazard to nesting birds, their eggs and young birds.

A phenoxy herbicide such as 2,4-D, on the other hand, can be applied from the roadway to adjoining roadsides and ditch banks with little chance of damaging eggs or injuring or killing birds and other wildlife. The herbicide can be applied early in the season (usually sometime in June) in time to prevent the production of weed seeds. A mowing along the edge of

the roadside after the nesting season and after grasses are mature is all that is needed to reduce snow pileup in the roadway during the winter months. The use of herbicides on a "spot treatment" basis to control patches of noxious weeds and troublesome brush is less expensive and less time consuming than mowing. Phenoxy herbicides should also be applied in early fall to suppress perennial weed regrowth and weaken the plants for the following year.

Minnesota Noxious Weed Law

Nine weeds are designated as noxious weeds in the state of Minnesota. These weeds are deemed by the Commissioner of Agriculture to be injurious to public health, public roads, crops, livestock or other property. In addition, there are 47 weeds on a secondary weed list in the state. The Minnesota Commissioner of Agriculture may, without further hearing, take a weed or weeds from this secondary list and add it to the noxious weed list on a county basis if: (1) a majority of township boards and city mayors in a county file a petition requesting this addition, (2) the petition is approved by the County Board of Commissioners, and, (3) the Commissioner of Agriculture deems the weed or weeds to be a problem.

The land owner, his agent, or the public official in charge of the land, if it is public land, is responsible to see that noxious weeds growing theron are controlled. Weed control is generally understood to mean preventing weeds from going to seed. Weeds not adequately controlled can be ordered destroyed or eradicated. Destroying or eradicating weeds refers to "complete killing of weeds, both the top growth and underground propagating parts of such weeds". If weeds are not controlled, an official notice may be served by the local weed inspector (township officers or municipal mayor or president), by the County Agricultural Inspector, the district inspector, the state supervisor, or by the State Commissioner of Agriculture. The official notice (Form #1) must contain the following information:

1) Kinds of weeds
2) How to destroy or eradicate these weeds
3) The number of days allowed to comply with the notice
4) Signature of local or County Agricultural Inspector

The nine weeds on the noxious weed list in Minnesota are (1) four herbaceous perennials: Canada thistle, perennial sowthistle, field bindweed, and leafy spurge; (2) three biennials: bull thistle, musk thistle and plumeless thistle; (3) one annual: wild hemp and (4) one woody perennial: poison ivy. In addition to these noxious weeds, the Minnesota Department of Transportation lists ragweed species and common dandelion as additional weeds to be controlled along public highways to improve the roadside environment for human health considerations.

Selection of Herbicides for Use Along Roadsides, Ditch Banks or other Rights-of-Way (Non-cropland)

1. 2,4-D

2,4-D is a phenoxy or chloro-phenoxy herbicide that is formulated as an amine, oil-soluble amine or low-volatile ester. It is usually the first choice of an herbicide for weed control along rights-of-way because it has little effect on grasses, is effective on a large number of broadleaf weed species and woody plants, is relatively low in cost and is usually readily available. These 2,4-D formulations are low in volatility and are less hazardous to use than the more volatile formulations. Highly volatile formulations, such as butyl ester of 2,4-D, should not be used for right-of-way spraying because vapors may drift and cause injury to nearby desirable plants.

2,4-D will control some woody species such as aspen (poplar), willow and boxelder. However, ash, maple, oak and several other common woody species are resistant to 2,4-D. If these brush species are present, 2,4-D can be mixed with another herbicide, such as 2,4-DP, to control a wide variety of broadleaf weeds and brush. 2,4-D may be used along drainage ditch banks or adjacant to home yards. However, when using 2,4-D or any herbicide used for vegetation control along rights-of-way, precautions must be taken to avoid wind drift to susceptible broadleaf crops, trees, ornamentals or other desireable plants. Drift hazard can be reduced by using low sprayer pressure, preferably no more than 30 to 40 psi (pounds per square inch), using a higher gallonage of water per acre and larger nozzles, by not spraying on windy days, or by using invert emulsions or spray-thickening agents. 2,4-D is rapidly broken down on plant foliage and in the soil, and is not considered a persistant herbicide. For example, 2,4-D may be used on grass pasture if a 7 to 14 day waiting period is observed before grazing dairy cattle on treated areas. Beef cattle should be removed from freshly treated areas for 7 days before slaughter. Check the product label for specific limitations.

2. 2,4-DP

2,4-DP is a phenoxy compound closely related to 2,4-D. 2,4-DP may be used alone, or in combination with 2,4-D to control many 2,4-D resistant broadleaf weed or brush species. 2,4-DP is not cleared for use on pastures, but may be used along drainage ditch banks and on non-cropland areas. The herbicide is not considered persistent and will break down within a few weeks of application.

3. Picloram (Tordon, Amdon)

Picloram is formulated as a 2 lb/gal liquid or as either a 10 percent or 2 percent granule or bead. Picloram is a very persistent broadleaf weed and woody plant killer that can be used along roadsides and other rights-of-way to kill phenoxy-resistant weeds or brush. It should not be used along drainage ditches or along streams, lakes, ponds or water runoff areas. Picloram is cleared for spot treatment and broadcast use in grass pastures in Minnesota for the control of 2,4-D resistant broadleaf weeds

and brush. Picloram is useful for spot treatment of deep rooted perennials such as leafy spurge, or hard-to-kill woody and fern species such as ash and bracken fern. Because of its longer persistence in soil as compared to 2,4-D and other phenoxy herbicides, and because many broadleaf crops and ornamental plants, including trees and shrubs, are very susceptible to injury from picloram, great care should be taken to avoid drift or misapplication to non-target areas. Picloram has been designated as a restricted use pesticide by the Environmental Protection Agency, and most formulations can only be applied by a certified applicator. Refer to the product label for additional information.

4. MCPA

MCPA is a phenoxy herbicide that is formulated as an amine, an ester or a sodium salt. It is normally not used for roadside or other rights-of-way spraying, but could be used to control certain broadleaf weed or brush species such as spotted knapweed, buttercup, burcucumber, or honeysuckle on which it is more effective than 2,4-D. MCPA is cleared for use on grass pastures with no limitation on use and is non-persistant.

5. MCPP (mecoprop)

MCPP is another phenoxy herbicide closely related to MCPA. MCPP may be used alone or in combination with 2,4-D and/or dicamba (Banvel) for the control of 2,4-D or MCPA resistant broadleaf weeds or brush. MCPP alone, and in various combinations, is cleared for use on lawns and other turf areas, and on non-cropland, but is not yet cleared for use on grass pastures in Minnesota. However, additional clearances are being sought and are expected shortly.

6. Dicamba (Banvel)

Dicamba is labeled for use along roadsides, but because of the great sensitivity of soybeans and most other legume and broadleaf crops and woody plants to dicamba, this herbicide should not be used to spray roadsides and other rights-of-way that are in the vicinity of susceptible field crops, ornamentals, trees and vegetable or fruit crops. Dicamba may be used in combination with 2,4-D to control a broad spectrum of broadleaf weeds and brush where the drift hazard is not a problem. Dicamba is also formulated as a granule, which greatly reduces the drift hazard. However, dicamba is very water soluble, and high rates should not be used along ditches carrying water. Dicamba may be used in grass pastures for broadleaf weed control and has a limitation to exlude dairy cattle from grazing treated areas for 7 days after application of 1/2 lb or 21 days after application of 1 lb of dicamba. For use of higher rates, see product label.

Note: Before any weeds can be sprayed or otherwise controlled in public waters (rivers, lakes, streams) in the state of Minnesota, a permit must be secured from the Department of Natural Resources, Centennial Office Building, St. Paul, MN.

Mowing roadsides for forage use

In some areas, farmers wish to mow the roadside once or twice each season and harvest the forage as feed for livestock. This practice is particularly desirable to the landowner on wide roadways and medians where past use of herbicides has eliminated most of the broadleaf weeds and brush. Where this practice is common, highway crews should not spray these areas prior to mowing, or if spraying is necessary, they can spot spray with a herbicide such as 2,4-D so the forage can be harvested for hay after a two week waiting period. If certain poisonous broadleaf weeds such as waterhemlock or bracken fern are present, the farmer should be alerted to the possibility of livestock poisoning from these weeds, and if present, poisonous plants should be controlled with herbicides prior to harvest, or harvesting these areas should be delayed until after chemical treatment and required waiting period. Farmer mowing of the roadway and utilization of this unused resource as livestock feed is looked upon as a benefit to both the farmer and the municipality and is encouraged in some areas. However, regular mowing may destroy the area for wildlife food and cover. Therefore, a system of partial or rotational mowing of an area is desirable, with some sections of roadside being left unmowed each year for wildlife utilization.

Types of herbicides

Herbicides such as 2,4-D and 2,4-DP are called "selective herbicides" because they will selectively control broadleaf weeds with little or no injury to the grasses. Also, they will selectively control deciduous (broadleaf) woody plants with little or no injury to evergreen (coniferous or needle-bearing) trees. Many selective herbicides, however, may become non-selective if the application rate is increased over the recommended amount.

Another group of herbicides is called "non-selective herbicides". Non-selective herbicides are chemicals that "burn off" or kill all vegetation and may leave the soil non-productive (barren) for a year or more. Some of these complete vegetation control chemicals may be needed around highway guardrails, signs, and around buildings or industrial sites to eliminate fire hazards or to reduce hand labor weed control efforts.

Herbicides may be classed as to their types of applications. Foliarly applied herbicides such as 2,4-D, or paraquat must be applied to the foliage and are not effective if applied to the soil at the rates commonly used. Other herbicides, such as bromacil or simazine, are taken up mainly by plant roots from the soil and do not need to have plant foliage present when the application is made. Herbicides may also be classified as to their mode of action. A contact herbicide, such as paraquat, kills above ground plant tissue only and does not translocate into the root system. 2,4-D is a good example of another type of herbicide - a "translocated herbicide". It moves into the root system from the foliage. These translocated herbicides can kill many perennial weed and brush species. A contact herbicide will not. Herbicides may also be classed as residual and non-residual chemicals. Most herbicides used along roadsides, such as 2,4-D and 2,4-DP are considered to be non-residual chemicals because they break

down rapidly and are gone in a few weeks or months. Some herbicides, such as the soil-sterilants already mentioned, are considered residual chemicals and may persist in the area of application for several years.

Selection of the best herbicides or herbicide combination

There are two primary considerations in selecting a herbicide for weed and brush control along highways or other rights-of-way. The first consideration may be safety to non-target plants and other organisms, including the applicator. The second and equally important consideration is performance or effectiveness of the herbicide.

Crops, trees and other broad-leaved plants adjacent to rights-of-way may be injured by herbicides in two main ways, (1) wind drift of the herbicides as it is being applied or (2) vapor drift, by volatility of certain formulations of a herbicide after application, which is evaporation of the herbicide into the air (especially troublesome on hot days) and subsequent drift of these vapors to sensitive plants, which can happen two or three days or more after application. Wind drift can be minimized by using low sprayer pressure, using higher gallonage nozzles, and by not spraying when the wind exceeds 5 to 10 mile per hour. In addition, invert emulsions (water-in-oil droplets rather than oil-in-water), which have the consistency of mayonnaise, can be used to reduce or prevent wind drift. Spray thickening agents of various kinds can also be used to reduce drift potential. Volatility can be minimized by choosing low-volatile herbicides or herbicide formulations. Among the herbicides, dicamba (Banvel) is the cause for most concern. It should be used only when sensitive plants are not in the vicinity. Among formulations, high volatile esters of 2,4-D should not be used because of the possiblity of vapor drift. Safety to the applicator may be accomplished by strict adherence to label precautions and safe equipment operating procedures.

Effective herbicide performance is dependent on proper identification of the weed or brush species to be controlled and the careful selection of herbicides or herbicide combinations that are most effective in controlling those species. Refer to "Systemic Herbicides for Weed Control", No. AD-BU-2281, to herbicide labels or to this publication (Table 1) to determine the best herbicide for a particular weed problem.

Time of application of herbicides

For best results, foliarly applied herbicides such as 2,4-D should be applied when perennial weeds are 6 to 8 inches tall and up to bud stage. Brush should be fully leaved out and growing rapidly. Perennial weeds should normally not be sprayed early in the spring when they are 2 to 3 inches tall or less because not enough spray will usually be retained on the foliage to kill the root. Also, the early spring flow of nutrients from root to shoot to support early spring top growth limits herbicide movement from shoot to root and results in poor control. Herbicides may also be applied in the fall up until frost, but if perennial weeds are mature or nearing maturity and seed production has occurred, it is more effective to mow perennial weeds and then spray the regrowth when it is 6 to 8 inches tall. Application of herbicides in the fall, when crops and

gardens are nearing maturity, will often result in much less injury to non-target plants.

Summary of principal considerations for spraying rights-of-way with herbicides

1. Identify weeds and brush to be controlled.
2. Select best herbicide or combination of herbicides for control. (Tables 1,2,3 or 4)
3. Select a low-volatile ester, amine or formulation of 2,4-D to reduce or eliminate the danger of vapor drift.
4. Calibrate the sprayer to determine output per acre or per unit area (using linear feet of miles of roadway sprayed x width of area sprayed and measurement of water used to spray an area).
5. Put the right amount of herbicide concentrate in the tank for each tankful.
6. Use low pressure (no more than 30 to 50 psi) to minimize spray drift.
7. Don't spray when the wind speed is excessive (preferably not over 5 miles per hour). Use an invert emulsion or spray thickening agent to reduce drift, if necessary. Avoid direct spraying of herbicides onto non-target plants.
8. Spray early in the season (usually in June) to perennial weeds in the bud stage, to brush that is fully leaved out, or spray in the fall when perennial weeds have new short growth of 8 inches or more.
9. Prevent herbicide spills on clothing or skin, follow safety precautions listed on label.
10. Do not use picloram (Tordan) or high rates of dicamba (Banvel) along drainage or irrigation ditches or along streams, lakes, or other open water.
11. Keep a complete record of spraying operations, recording chemical used, weather and wind conditions at time of spraying, date sprayed, etc.

Application of herbicides along rights-of-way

There are two principal methods of herbicide application used along rights-of-way. First, and perhaps the most common, is the use of a broad jet or gun type nozzle that makes use of considerable pressure, usually more than 50 pounds per square inch, to direct the spray at the weeds and brush to be controlled. This method utilizes relatively large gallonages of 50 to 200 gallons of water per acre and wets the foliage to the point of run-off. The spray is prepared by mixing the desired quantity of herbicide concentrate in the estimated gallonage of spray to be applied. A more accurate estimation can be made of sprayer output by measuring a roadside or right-of-way area, then computing the acreage involved (43,560 sq ft = 1 acre), spraying it with water only, and determining the gallonage applied per acre. Then the proper amount of herbicide concentrate can be put in the tank for the size of batch being mixed.

The second method of spraying rights-of-way is using a boom on either ground or aerial equipment. The boom type sprayer delivers a much more accurate and uniform spray pattern, gives better coverage of plant foliage, and can utilize smaller gallonages of water (as little as 15 to 20 gallons per acre will give adequate coverage in many cases). When using ground equipment, the height of the boom must be adjusted to give a uniform spray

pattern, and all nozzles should be calibrated to make sure they are delivering the same volume of spray. The sprayer should be calibrated by determining sprayer output per acre or by linear feet of right-of-way sprayed and then putting the proper amount of spray concentrated in the tank for the gallonage of spray being delivered per unit area.

Right-of-way spraying examples

1. Suppose you are to operate a broadjet sprayer to apply herbicides along a road right-of-way. There is mixed hardwood brush, Canada thistle and other broad-leaved weeds to be controlled. You have been asked to apply a mixture of 2,4-D and 2,4-DP at 1 lb of each component per acre. The label on the product stated that there are 2 lbs of 2,4-D and 2 lbs of 2,4-DP acid equivalent per gallon. The label also states that the material is a low-volatile ester formulation and an emulsifiable concentrate in liquid form.

Question 1 - How much product, as it comes from the container, should you apply per acre?_____

2. You wish to calibrate your sprayer to determine approximate sprayer output per acre. There is a 320 gallon tank on the sprayer graduated in 10 gallon increments. You wish to mix a full batch of spray each time you fill. You fill the spray tank with water in preparation for a test run. You measure off a distance of 330 feet on the roadway and determine that the width of the area to be sprayed on each side of the roadway is approximately one rod (16.5 feet). From a "running start" at a sprayer pressure of 40 pounds per square inch (psi) and at uniform speed, spray the foliage on one side of the roadway for the 330 feet distance just as you would if you were using the herbicide. Spray to the point of runoff, moving the nozzle gun smoothly and uniformly to achieve good coverage of the weeds and brush to be controlled. Then you refill the tank, and by measuring the amount needed you determine that you used 10 gallons of water to cover the test area. There are 43,560 square feet/acre.

Question 2 - What fraction of an acre did you spray?_____

Question 3 - What gallonage are you applying per acre?_____

Question 4 - How many acres can you spray per tankful?_____
There are 5,280 feet per mile.

Question 5 - How many miles of roadway (spraying both sides) can you spray per tankful?_____

Answers: 1) 1/2 gallon; 2) 1/8 acre; 3) 80 gpa; 4) 4 acres; 5) 1 mile.

Table 1. Susceptibility of noxious and other undesirable weeds and brush to phenoxy herbicides 1/

Plant	Life cycle	2,4-D	2,4-DP
Field bindweed	Perennial	Fair	Fair
Leafy spurge	Perennial	Poor	Fair
Canada thistle	Perennial	Fair	Fair
Perennial sowthistle	Perennial	Fair	Fair
Bull thistle	Biennial	Excellent	Excellent
Musk thistle	Biennial	Good	Good
Plumeless thistle	Biennial	Good	Good
Hemp	Annual	Good	Good
Poison ivy	Woody perennial	Fair	Good
Common ragweed	Annual	Excellent	Excellent
Giant ragweed	Annual	Excellent	Excellent
Common dandelion	Perennial	Excellent	Excellent
Ground Ivy (Creeping Charlie)	Perennial	Fair	Good
Common chickweed	Annual	Fair	Good
Waterhemlock	Perennial	Good	Good
Ash	Woody perennial	None	Poor
Boxelder	Woody perennial	Good	Good
Buckbrush	Woody perennial	Good	Good
Elm	Woody perennial	Poor	Fair
Aspen (poplar)	Woody perennial	Fair	Fair-Good
Oak	Woody perennial	Poor	Fair-Good
Willow	Woody perennial	Good	Good
Maple	Woody perennial	Poor	Fair

1/Adapted from Farmer's Bulletin No. 2183 USDA, Using Phenoxy Herbicides Effectively, and from research trials.

Table 2. Summary of herbicides for broadleaf weed and brush control on roadsides and drainage ditch banks.

Chemical	lb/A	Time of application	Precautions
For thistles and other broadleaf weeds			
2,4-D amine or L.V. ester	2	When perennial broadleaf weeds are 6 to 10 inches tall and before bud stage or in the fall on active new weed growth.	Use low pressure (30-40 psi). Avoid drift. 2,4-D may be used along drainage ditches. Glean should not be used near water or drainage ditches.
Chlorsulfuron (Glean)	1/4 oz-2 oz/acre		
For broadleaf weeds and 2,4-D resistant brush			
2,4-DP	2	When brush is fully leaved out and before bud stage of broadleaf weeds or in the fall on active new weed growth.	Avoid drift. May be used along drainage ditch banks.
2,4-D + 2,4-DP	1 + 1		
MCPP (mecoprop)	2		
2,4-D + MCPP + dicamba (Trimec-352)	2 + 1 + 0.2		
2,4-D + MCPP + dicamba (Trimac 4-41)	1.88 + 2 + 0.5		
For spot treatment of 2,4-D resistant broadleaf weeds or brush			
Picloram (Tordon, Amdon)	1/2 to 1	When brush is fully leaved out and before bud stage of broadleaf weeds or in the fall on active new weed growth.	Picloram is a persistent and water soluble herbicide. (Restricted use material.) Do not use these herbicides along drainage ditch banks or along streams, lakes or water supplies. Avoid drift to non-target broadleaf plants.
Picloram + 2,4-D (Amdon 101 Tordon 101)	1/2 + 1		
Dicamba + 2,4-D (Banvel 720)	1 + 2		
Brush control			
Fosamine (Krenite)	6 to 12	Apply during the 2 month period prior to fall leaf coloration.	May be used on drainage ditch banks.

Table 3. Chemicals for temporary or short-term vegetation control (non-cropland, fence rows, highway guardrails, parking lots, building sites, etc.

Grasses and cattails	Broadleafs	Grasses and broadleafs
dalapon (Dowpon M) (Basfapon)	2,4-D	paraquat
TCA	2,4-DP	amitrole
dalapon and TCA (Dowpon C)	MCPP	amitrole - T
	picloram (Tordon, Amdon) 1,2/	glyphosate (Roundup)
	MCPA	ammonium-sulfamate (Ammate)
	dicamba (Banvel) 2/	
	2,4,5,-T or Silvex 3/	

1/ Restricted use herbicide. May be applied only by a certified applicator.

2/ Water soluble compounds. Use with caution around desirable broadleaf plants, trees and shrubs.

3/ May still be used on certain non-cropland sites such as airports, fencelines not adjacent to pasture, lumber yards, refineries, storage areas, tank farms or industrial sites (not otherwise included in suspended uses).

Table 4. Chemicals for long-term vegetation control (non-selective) (non-cropland, fence rows, highway guardrails, parking lots, building sites, etc.)

Broadleaf and Grass Control

sulfomethureon methyl (Oust)

*bromacil (Hyvar-X, Hyvar-XL)

diuron (Karmex)

diuron/bromacil (Krovar, liquid; Bromex granules)

simazine (Princep)

atrazine (AAtrex, atrazine)

prometone (Pramitol)

simazine and amitrol (Amizine)

*AMS (Ammonium sulfamate) Ammate

borates

sodium chlorate

borax and 2,4-D (D.B. Granular)

*hexazinone (velpar)

*tebuthiuron (Spike - available as wettable powder or pellets)

* May also be used for spot treatment of brush species. However, these materials must be used with caution because the roots of desirable trees or shrubs may pick up and translocate these materials.

Table 5. Cut stump treatment of brush and trees.

2,4-D + 2,4-DP + penetrating agent (Weedone CB - apply undiluted
Dicamba (Banvel CST) - apply undiluted
Dicamba + 2,4-D + oil or diesel fuel as carrier
Picloram (Tordon 101R, Tordon RTU) - apply undiluted
Ammonium sulfamate (Ammate) - apply as crystals or water base spray
Triclopyr (Garlon) - apply undiluted or mix with diesel fuel

HERBICIDES

This is a listing of some herbicides now sold for major crop use in Minnesota. The application rate refers to pounds of active ingredients or acid equivalent per acre on a broadcast basis. The information given is not intended to replace label instructions; follow label instructions closely. Refer to Agricultural Extension Service, University of Minnesota, fact sheets and folders on weed control by crop and to product labels for additional information.

Acifluorfen (Blazer) - Rohm and Haas

Use--Control of many annual broadleaf weeds in soybeans, including eastern black nightshade. Mixtures with bentazon (Basagran), chloramben (Amiden), fluazifop (Fusilade) and sethoxydim (Poast) are labeled. These mixtures will control more species of weeds than each chemical alone.

Rate of application--3/8 to 1/2 pound per acre.

Time of application--Postemergence; acifluorfen effectively controls most annual broadleaf weeds in soybeans when applied before the weeds exceed the four (4) true-leaf stage. Weeds treated after they exceed the maximum size listed on the herbicide label will not be adequately controlled. Top growth will die, but in most cases regrowth will occur from the roots or lower stems of larger established broadleaf weeds.

Remarks--Rain or irrigation within six (6) hours of application may reduce the effectiveness of acifluorfen. Hot and humid weather increases the effectiveness of acifluorfen. The herbicide should not be applied when recent daytime temperatures are below 70 degrees F.

Acifluorfen may cause minor temporary injury to treated soybean leaves. The injury will appear as a speckled yellowing, and/or crinkling of the treated leaves. The herbicide does not affect subsequent growth. Actively growing soybeans usually recover quickly.

Formulation--2 pounds per gallon liquid. The 2S formulation includes a surfactant. The 2L formulation does not contain a surfactant. Follow the label instructions for adding a surfactant or oil concentrate.

Alachlor (Lasso, Lasso II) - Monsanto

Use--Annual grass, pigweed, nightshade and nutsedge control in corn, dry beans, potatoes, sunflowers and soybeans; some broadleaf control. Use in preemergence mixtures with atrazine, cyanazine, dicamba, simazine, or linuron on corn; with linuron, chloropropham, bifenox, dinoseb, dinoseb + naptalam, chloramben or metribuzin on soybeans; and preplanting with trifluralin on dry beans. Used in minimum tillage corn with paraquat or glyphosate and atrazine, cyanazine, or simazine. In minimum tillage soybeans with glyphosate or paraquat and metribuzin or linuron.

Rate of application--2 to 4 pounds per acre on corn and soybeans, 2 to 3 pounds per acre on dry beans, and 3 to 4 pounds per acre on sunflowers in the liquid formulation.

--2.4 to 3.9 pounds per acre in the granular formulation on corn or soybeans.

Time of application--preplanting or preemergence; preplanting preferred for nutsedge control. Can be used with atrazine on corn up to the time corn is 5 inches tall or with dicamba until corn is 3 inches tall and weeds reach the 2-leaf stage. Postemergence treatments should not be applied with fluid fertilizer. Preplanting or preemergence applications may be applied with fertilizer solutions.

Remarks--Research results show good control of annual grasses, nutsedge, nightshade, pigweed, and fair lambsquarters control. Control of other broadleafs is not consistent. Alachlor alone or with atrazine can be applied with center pivot irrigation for corn. Adzuki beans are very susceptible to injury from alachlor.

Formulation--Lasso--4 pounds per gallon liquid.
Lasso II--15 percent granules
Lasso + atrazine--2.5 + 1.5 pounds per gallon dispersible liquid.

Ametryne (Evik) - Ciba-Geigy

Use--Annual weed control in corn.

Rate of application--1 1/2 to 2 pounds per acre.

Time of application--Postemergence directed after corn is at least 12 inches tall. Do not apply later than 3 weeks before tasseling.

Remarks--Care must be taken to avoid contact with corn leaves. A surfactant should be added. This is usually considered an emergency treatment. May be used for wild proso millet control when corn is more than 12 inches tall and millet is less than 4 inches tall.

Formulation--80 percent wettable powder.

Atrazine (AAtrex and several other trade names) - Ciba-Geigy, Shell and others

Use--Weed control in corn, sorghum, and proso millet. Effective in controlling quackgrass with a fall and/or early spring application followed by plowing. Only corn can be planted following treatment. Used in mixtures with alachlor, dicamba, cyanazine, pendimethalin, glyphosate, linuron, metolachlor, paraquat, simazine or propachlor and with butylate or EPTC plus crop protectant on corn.

Rate of application--(1) Weed control in corn: 1.2 to 3.0 pounds per acre. Use higher rate on fine-textured soils or soils with high organic matter. (2) Weed

control in sorghum: 2 to 3 pounds per acre. (3) Quackgrass control: 3 to 4 pounds per acre; a split application of 2 pounds per acre in the fall before plowing and 2 pounds per acre in the spring works best on quackgrass. (4) Weed control in proso millet: 1/2 to 2 pounds per acre.

Time of application for weed control in corn and sorghum--Preemergence or preplant in corn and postemergence in corn and sorghum before grasses are 1-1/2 inches or broadleaf weeds are 4 inches tall. Atrazine is cleared for use on corn up to layby-stage (about 30 inches tall) of the corn. Addition of emulsifiable petroleum or vegetable oils has improved performance of postemergence atrazine sprays on corn. Various formulations of surfactants and detergents used with atrazine have not improved weed control as much as the use of oils. Apply preplanting or preemergence for weed control in proso millet.

Remarks--Susceptible crops have been injured in rotation following treated crop. To minimize injury to susceptible crops following corn, use the lowest rate consistant with good weed control; use band applications rather than broadcast applications and thoroughly till soil before planting susceptible crops. Cool temperatures can increase the possiblility of corn injury. Do not graze or feed treated corn or sorghum for 21 days after postemergence application.

Formulation--80 percent wettable powder, 4 pounds per gallon dispersible liquid, 90 percent water dispersible granule.

Barban (Carbyne) - Velsicol

Use--Control of wild oat in wheat, barley, flax, soybeans, sugarbeets, sunflowers and peas.

Rate of application--1/4 to 3/8 pound per acre on wheat, barley, and flax; 3/4 to 1 pound per acre on sugarbeets; 3/8 pound per acre on sunflowers and soybeans used in mixtures with diclofod and difenzoquat in wheat.

Time of application--Postemergence, when most wild oat are in 2-leaf stage (from the time the second leaf first appears until the third leaf first appears). Time of application is critical. Spray peas before the 6-leaf stage, flax before the 12-leaf stage, and within 30 days of emergence of sugarbeets, sunflower, mustard, and soybeans. Sequential applications (2 sprays of barban) each at 1/4 pound per acre may be made to barley and wheat. Make the first application when the majority of the wild oat are in the 2-leaf stage. The second application (if needed) may be made when the second flush of wild oat are in the 2-leaf stage. If the first application is missed, a single application of 1/2 pound per acre may be made in the 2-1/2 to 3-1/2-leaf stage.

Remarks--Flax and small grain injury sometimes occurs; injury on flax has been more severe. Observe feeding restrictions on label. Do not spray when plants are wet with dew or rain. Spray only when crop is actively growing and not under stress.

Formulation--2 pounds per gallon liquid.

Benefin (Balan) - Elanco

Use--Annual grass control in seedling legumes.

Rate of application--1-1/8 to 1-1/2 pounds per acre.

Time of application--Preplanting. (Do not apply after seeding)

Remarks--Must be incorporated into soil by disking in two different directions before planting. May be mixed with fluid fertilizers.

Forumulation--1-1/2 pounds per gallon liquid.

Bentazon (Basagran) - BASF

Use--Control of most annual broadleaf weeds, inluding hairy nightshade, Canada thistle, and nutsedge in soybeans, corn, dry or succulent edible beans and peas; in a mixture with atrazine for postemergence use in corn; mixtures with acifluoren (Blazer) and sethoxydim (Poast) are labeled for soybeans.

Rate of appication--3/4 to 1-1/2 pounds per acre in soybeans and corn; 3/4 to 1 pound per acre in dry and succulent edible beans and peas. Lower rates are for small, susceptible weeds; higher rates are for larger or more tolerant weeds. Oil concentrate at 1 quart/A can be used in all labeled crops except peas when ground application equipment is used.

Time of application--Postemergence Bentazon is most effective when the weeds are in the 2- to 4-leaf stage. Soybeans, dry beans, snap and green beans usually have the first to second trifoliolate leaf when the weeds are at the correct size for treatment. Corn is tolerant at all stages, but is usually sprayed when corn has 1 to 5 leaves. To improve control of lambsquarters and pigweed in corn, a postemergence mixture of bentazon, atrazine and oil concentrate can be used. Peas may be treated after 3 pairs of leaves (4 nodes) are present. Do not apply to crops growing under stress such as drought, cold weather, or previous herbicide injury. On thistle and nutsedge, treat when the weeds are 8 to 12 inches and apply a second application 10 days after the first. Do not apply more than a total of 2 pounds of bentazon per acre in one crop year.

Remarks--Rain or irrigation within 24 hours after application may reduce the effectiveness of bentazon. Weed control has been more consistent from applications made during the day than from early morning, late evening, or night applications. Applications made when plants are dry are more effective.

Formulation--4 pounds per gallon liquid.

Bifenox (Modown) - Rhone-Poulenc

Use--Control of some annual broad-leaved weeds in soybeans. May be used alone or as a preemergence application after trifluralin, or in a preemergence mixture with alachlor.

Rate of application--1.6 to 2 pounds per acre.

Time of application--Preemergence.

Remarks--Soybean tolerance is limited and malformation and stunting of young soybeans often occur. Grass control has been inconsistent. Do not apply after soybeans start emerging.

Formulation--80 percent wettable powder, 4 pounds per gallon liquid.

Bromoxynil (Brominal, Brominal-4E, Buctril) - Union Carbide, Rhone-Poulenc

Use--Annual broadleaf control in corn, wheat, barley, oats, rye, flax, and newly planted grasses for sod and seed production. Used in mixture with MCPA ester in wheat, barley, and oats. This mixture may be tank-mixed with difenzoquat (Avenge) to control wild oats or diclofop (Hoelon) to control annual grasses and broadleafs in wheat and barley. Mixtures with atrazine or 2,4-D are labeled in corn.

Rate of application--1/4 to 1/2 pound per acre; 1/4 pound per acre in mixture with MCPA at 1/4 pound per acre.

Time of application--From 2-leaf to early boot stage of wheat, oats, or barley. When corn is less than 14 inches tall. When flax is 2 to 8 inches tall. Early applications more effective on weeds. Treat broadleafs before the 5-leaf stage. Do not treat flax in humid weather or when temperature is over 80 degrees F.

Remarks--Controls wild buckwheat and smartweed better than MCPA or 2,4-D. Does not control perennials. Injures legumes. Some small grain and corn leaf burn has occurred at higher rates.

Formulation--2 or 4 pounds per gallon liquid. Formulations of 2 or 3 pounds per gallon of bromoxymil + 2 or 3 pounds per gallon of MCPA ester are available (Brominal Plus, Brominal 3+3, Bronate).

Butylate (Sutan +) - Stauffer

Use--Control of annual grasses and nutsedge in corn. Used in mixtures with atrazine or cyanazine for annual grass and broadleaf control. A three-way mixture with atrazine and cyanazine is labeled.

Rate of application--3 to 6 pounds per acre.

Time of application--Preplanting, fall preplanting between October 1 and November 15.

Remarks--Must be incorporated into the soil. Proper incorporation can be accomplished by disking field twice, once in each direction, immediately after applying chemical. Sutan + contains a chemical additive to prevent corn injury.

Can be applied alone or with atrazine or cyanazine with dry bulk or fluid fertilizer. Sutan + is labeled for use in center pivot irrigation systems.

Formulation--6.7 pounds per gallon liquid, 10 percent granular, 4.8 pounds butylate plus 1.2 pounds atrazine per gallon liquid (Sutazine).

Chloramben (Amiben) - Union Carbide

Use--Preplanting and preemergence control of annual broadleaf weeds and annual grasses in soybeans, sunflowers, and dry edible beans, including adzuki beans. Postemergence applications can be made to soybeans up to the second trifoliolate leaf stage. Chloramben is labeled for tank mixing with trifluralin, ethalfluralin, pendimethalin, vernolate, linuron, alachlor, dinoseb, metribuzin, metolachlor, and 2,4-DB.

Rate of application--1.8 to 2.7 pounds per acre preplanting on preemergence; 2-1/4 to 2.7 pounds per acre postemergence. For wild proso millet control, chloramben may be applied preplant incorporated at 1.8 to 2.7 lb/A followed by a postemergence application of 1.8 to 2.7 lb/A, when soybeans are in the cotyledon to second trifoliolate stage, but before emergence of wild proso millet.

Time of application--Preemergence, preplant incorporated or on soybeans, up to the second trifoliolate leaf stage of soybeans.

Remarks--Chloramben must be moved into the soil by rainfall or incorporated before weeds sprout to be effective. Incorporated treatments result in improved weed control under dry conditions, however, preemergence applications are more effective when rainfall occurs soon after application. Excessive moisture may leach chloramben below the zone of weed seed germination. This is particularly true in coarse textured (sandy) soils. Chloramben may be applied early postemergence from the cracking to second trifoliolate stage of soybeans.

Early stunting of soybeans has been observed under some conditions, but the crop usually outgrows the injury. Chloramben is cleared for use on corn at 0.9 to 1.8 pounds per acre, but experiment station tests showed a definite injury potential to corn and erratic weed control at these rates. Severe stunting of corn occurred in some fields following heavy rains.

Formulation--1.8 pounds per gallon liquid; 10 percent granule; 75 percent DS (dry soluble)

Chlorpropham (Furloe) - PPG

Use--Annual smartweed control in soybeans.

Rate of application--2 to 3 pounds per acre.

Time of application--Preemergence or preplanting.

Remarks--May be used preplanting in mixtures with alachlor, paraquat, trifluralin, or vernolate. Does not control weeds other than annual smartweed.

Formulation--4 pounds per gallon liquid.

Chlorsulfuron (Glean) - DuPont

Use--Control of most broadleaf and several grass weeds in wheat and barley.

Time of application--Preemergence or postemergence, but early postemergence use of chlorsulfuron plus a surfactant appears to be the most effective method of application in Minnesota.

Remarks--Chlorsulfuron is a very active herbicide. Rates of 1/8 to 1/2 ounce/A of the 75 percent dry flowable formulation are effective in controlling many common small grain weeds. Chlorsulfuron persists in high pH soils and causes injury to broadleaf crops following in the rotation. Chlorsulfuron is not labeled for use in soils with a pH above 7.5. A test strip of rotational crops must be successfully grown to maturity in the year prior to the production year. See label before using.

Formulation--75 percent dry flowable, water dispersible, granule.

Cyanazine (Bladex) - Shell

Use--Annual grass and broadleaf control in corn. Preemergence with atrazine, pendimethalin (Prowl), paraquat, metolachlor (Dual), or alachlor (Lasso). Preplanting with alachlor (Lasso), metolachlor (Dual), butylate (Sutan +), or EPTC (Eradicane). Used for minimum tillage corn with paraquat. Used preemergence on grain sorghum in mixtures with propachlor.

Rate of application--1.25 to 4.75 pounds per acre depending on soil texture and organic matter, 0.6 to 3.0 pounds per acre with alachlor, butylate, EPTC (Eradicane), or metolachlor.

Time of application--Preplanting, preemergence, or postemergence on corn through the 4-leaf stage and before weeds exceed 1-1/2 inches. For postemergence, use only the 80 percent wettable powder or 90 percent dry flowable, not the 4 pounds per gallon liquid dispersible formulation.

Remarks--Do not add petroleum oils to postemergence applications or severe corn injury may result. When applied postemergence under droughty or arid conditions, certain surfactants or emulsifiable vegetable oils may be used with the wettable powder formulation, but under moist conditions, these additives may cause severe corn injury. Can be applied preemergence with fluid fertilizer or through center pivot irrigation systems. Cool temperatures, rain, or dew can increase potential for injury.

Formulation--80 percent wettable powder, 4 pounds per gallon dispersible liquid, 15 percent granule, 90 percent dry flowable water dispersible granule.

Cycloate (Ro-neet) - Stauffer

Use--Annual grass, nutsedge, and broadleaf control in sugarbeets.

Rate of application--3 to 4 pounds per acre.

Time of application--Preplanting; fall or spring.

Remarks--Must be incorporated immediately and thoroughly, tillage tool should be operated 4 to 6 inches deep to incorporate to a depth of 2 to 3 inches.

Formulation--6 pounds per gallon liquid, 10 percent granules.

2,4-D - (Various trade names and manufacturers)

Use--Broadleaved weed control in corn, small grains, and grass pastures. Mixtures with dicamba are labeled.

Rate of application--Corn and small grains: 1/6 to 1 pound per acre depending on formulation used, method of application, the size and kinds of weeds, weather conditions, and stage of crop growth. See label. Grass pastures: 1 to 2 pounds per acre depending on kind of weeds to be controlled.

Time of application--Postemergence. Corn--4 inches to tasseling or after dough stage. Use drop nozzles after corn is 8 inches tall. Wheat and barley--5th leaf to early boot; oats--6th leaf to early boot; pastures--spring or fall when weeds are actively growing.

Remarks--Do not graze dairy cattle for 7 to 14 days after treatment of pastures with 2,4-D (see label).

Formulation--Liquids of various concentrations.

Dalapon (Dowpon M, Dalapon-85)- Dow

Use--Grass control in flax and sugarbeets. Quackgrass control in the fall before planting corn, potatoes, dry beans, or sugarbeets in the spring.

Rate of application--(1) Flax: 3/4 pound per acre. May be tank-mixed with 1/4 pound per acre of MCPA on flax. (2) Sugarbeets: 2 to 3-1/2 pounds per acre. (3) 6 to 11 pounds per acre for fall quackgrass control.

Time of application--(1) Flax and sugarbeets: when grasses are not more than 2 inches tall. Postemergence until sugarbeets reach 6-leaf stage, directed from 7-leaf stage until beets are 14 inches. (2) For quackgrass control, apply on growing quackgrass; plow 10 days later.

Remarks--Adding a surfactant to the dalapon spray mix improves wetting and improves grass control.

Formulation--74 percent water soluble powder.

2,4-DB (Butoxone, Butyrac 200) - Vertac, Union Carbide

Use--Broadleaved weed control in seedling stands of alfalfa, birdsfoot trefoil, and clovers and established stands of alfalfa. Cocklebur control in soybeans. 2,4-DB is labeled for postemergence use with naptalam and as directed sprays with linuron and metribuzin in soybeans.

Rate of application--1/2 to 1-1/2 pounds amine and 1/2 to 1 pound ester per acre on forage legumes. 1/5 pound amine per acre on soybeans.

Time of application--Postemergence when seedling legumes have 1 to 4 trifoliolate leaves and weeds less than 3 inches tall or on established legumes in the fall when weeds are less than 3 inches tall. For cocklebur control in soybeans, apply as a directed spray when soybeans are 8 to 12 inches high and cocklebur no more than 3 inches tall.

Remarks--Do not spray drought stressed soybeans or soybeans that show symptoms of phytophthora root rot disease. Do not apply when extreme temperatures are expected within 2 to 3 days. Observe grazing and time of harvest precautions on the label.

Formulation--1.75 or 2 pounds per gallon liquid.

Desmedipham (Betanex), Desmedipham + Phenmedipham (Betamix) - Nor-Am

Use--Annual grass and broadleaf control in sugarbeets, less effective on grasses. Desmedipham is more effective on redroot pigweed than the mixture of desmedipham + phenmedipham.

Rate of application--1 to 1-1/4 pounds per acre of total active ingredient.

Time of application--Early postemergence after sugarbeets have four true leaves. Weeds should not have more than four true leaves for best control.

Remarks--Applications of desmedipham and phenmedipham following preplanting EPTC or preemergence TCA have sometimes resulted in sugarbeet injury. To reduce injury do not use more than 1 pound per acre where preplanting or preemergence herbicides have been used and do not apply if highest temperature expected during the day exceeds 85 degrees F. If temperatures are approaching this limit, application in the late afternoon will decrease injury potential. Split applications (use of a half-rate followed in 5 to 7 days by a second half rate) have reduced sugarbeet injury and improved weed control compared to a single

application at the full rate. Rainfall within 6 hours after spraying may reduce weed control.

Formulation--1.3 pounds per gallon liquid.

Diallate (Avadex) - Monsanto

Use--Control of wild oats in alfalfa, barley, flax, sugarbeets, potatoes, soybeans, forage legumes, corn, lentils, and peas.

Rate of application--1-1/4 pounds per acre barley; 1-1/2 to 2 pounds per acre on other crops.

Time of application--Preplanting on flax or sugarbeets; postseeding (pre-emergence) on barley. Fall application is a possibility before sugarbeets. Granules may be used in fall, but are not recommended for spring.

Remarks--Quite volatile and must be incorporated soon after application. Incorporated preplanting applications with disk, clutivator, or harrow to a depth of 2 inches. In postseeding applications, incorporate chemical with two harrowings at right angles. Small grain injury has been observed, particularly with preplanting application. Do not apply to field in ridged condition. This chemical irritates skin and eyes; use caution when handling. Diallate may persist in the soil enough to affect tame oats planted the next year.

Formulation--4 pounds per gallon liquid, 10 percent granules.

Diallate is a restricted use herbicide and can be applied only by a certified applicator. Adhere to ALL label directions concerning safe handling and use of this herbicide.

Dicamba (Banvel, Banvel II) - Velsicol

Use--Postemergence control of most broadleaved weeds except wild mustard in wheats, oats, corn, and grass pastures. Especially useful for controlling wild buckwheat and smartweed in wheat and oats. Can be used preemergence with alachlor or metolachlor, or as an overlay treatment until corn is 5 inches tall following butylate, EPTC +, alachlor, metolachlor, propachlor, atrazine, cyanazine or pendimethalin. May be applied postemergence on corn with 2,4-D or atrazine. No oil or surfactants should be added to postemergence applications.

Rate of application--1/8 pound per acre with MCPA at 1/4 pound per acre in wheat and oats; 1/4 to 1/2 pound per acre alone or with 2,4-D in corn; 1/4 to 8 pounds per acre in grass pastures; 1/4 to 1/2 pound per acre with alachlor preemergence on corn.

Time of application--From 2- to 5-leaf stage of wheat and oats. Up to time corn is 2 feet tall and not within 15 days of tasseling. Application made too close to tasseling can cause barren ears. When perennial broadleaf weeds are 8 to 12 inches tall and up to bud stage in grass pastures.

Remarks--Can be combined with MCPA in wheat and oats or with 2,4-D in corn for control of mustard and other broad-leaved weeds. If used in pastures, observe grazing restrictions on label. Do not mix additives with dicamba or crop injury may result. Do not apply preemergence on sandy soils or soils with less than 2 percent organic matter. Avoid spray or vapor drift to nearby susceptible broadleaf crops. Considerable drift injury has occurred in soybeans. To prevent drift, follow the application instructions on the label. Apply in 20 gallons or more water per acre; set pressure at 20 psi or less; do not apply to corn when soybeans in the area are over 10 inches tall; do not use on a day the temperature is expected to be over 85 degrees F.; apply when wind is less than 5 mph; do not apply after corn is 2 feet tall.

Formulation--2 or 4 pounds per gallon liquid; 5 percent granules; commercial combinations with MCPA and 2,4-D are available.

Diclofop (Hoelon) - American Hoechst

Use--Annual grass control in soybeans, wheat, and barley, including wild oat and volunteer corn.

Rate--3/4 to 1-1/4 pounds per acre for wheat and soybeans
--3/4 to 1 pound per acre for barley

Time of application--Diclofop effectively controls many annual grasses including wild oat and volunteer corn in fall and spring seeded wheat, spring seeded barley, and soybeans. Annual grasses including wild oat can be controlled with diclofop up to the 4-leaf stage. Use 1-1/4 pounds of diclofop per acre when the weeds have 3 to 4 leaves, lower rates when the weeds have 3 or fewer leaves. Treat yellow foxtail and crabgrass before they reach the 3-leaf stage. Volunteer corn should be treated after the corn plants have emerged, but before the tallest corn plants exceed 10 inches in height.

The time of diclofop application also depends on the crop. Fall and spring seeded wheat should not be treated after the 4-leaf stage. Spring seeded barley should not be treated after the 3-leaf stage. Injury may result from applications made after the crop exceeds the maximum labeled leaf stage. Soybeans should be treated before the formation of the sixth trifoliolate leaf.

Remarks--Diclofop is most effective when applied to weeds that are growing rapidly. Weed control may be reduced if treatment is made under dry soil conditions, or when weather conditions are otherwise not favorable for rapid growth.

Do NOT tankmix diclofop with any other pesticide and do NOT apply diclofop within 7 days of the application of another pesticide. The presence of another pesticide in the tank or on the leaves of treated weeds may reduce the effectiveness of diclofop. Do not apply more than one application of diclofop in a growing season.

Diclofop is a restricted-use pesticide and can be applied only by a certified applicator. Adhere to ALL label requirements concerning safe handling and use of this herbicide.

Formulation--3 pounds per gallon liquid.

Diethatyl (Antor)

Use--Control of pigweed and some annual grasses in sugarbeets.

Rate of application--4 to 6 pounds per acre.

Time of application--Preplanting incorporation or preemergence.

Remarks--Shallow incorporation (1 to 2 inch) gives best results.

Formulation--4 lbs. per gallon liquid.

Difenzoquat (Avenge) - American Cyanamid

Use--Controls wild oat in barley, all winter wheat varieties except Borah, WS 1877, WS 1809, WS 1859, Klasic, and Probrand, Era, Butte, Kitt, Solar, Cateau, Walera, Probrand 711, Olaf and Fortuna spring wheat, and all varieties of duram wheat except Lakota, Wascana, Vic and Edmore. Do not apply to hard red spring varieties not listed.

Rate of application--5/8 to 1 pound per acre depending on density of wild oat population (see label).

Time of application--Postemergence when majority of wild oat plants are in the 3- to 5-leaf stage of growth.

Remarks--Difenzoquat may be tank-mixed with 2,4-D or MCPA amine or ester, bromoxynil or a mixture of MCPA and bromoxynil. Do not apply mixture of difenzoquat and 2,4-D until the crop is 6 inches tall or until after the crop is well tillered. Apply difenzoquat in 5 to 20 gallons of water per acre by ground equipment or 3 to 10 gallons of water per acre by aircraft, but use a surtactant when applying over 10 gallons of water per acre. Do not apply before a rain or when plants are wet from dew or rain and do not make more than one application per season. Do not graze treated fields or cut treated forage for silage.

Formulation--2 pounds per gallon liquid.

Dinoseb (Premerge and others) - Vertac

Use--Control of annual weeds in dry beans, corn, forage legumes, small grains, and soybeans. In preemergence mixture with alachlor (Lasso) or chloramben (Amiben) on soybeans.

Rate of application--Varies with crop, soil type, and temperature. See label.

Time of application--Preemergence and/or postemergence depending on crop. Follow label instructions closely.

Remarks--Results vary with soil and temperature conditions. Crop injury may occur.

Formulation--Liquids of various concentrations.

Endothall (Endothal, Herbicide 273) - Pennwalt

Use--Control of annual smartweed, wild buckwheat, and marshelder in sugarbeets.

Rate of application--3/4 to 1-1/2 pounds per acre.

Time of application--Postemergence when sugarbeets have 4 to 6 leaves.

Remarks--Excessive injury, especially to very small sugarbeets, may occur if temperatures are above 80 degrees F. Poor weed control may result at temperatures below 60 degrees F.

Formulation--3 pounds per gallon liquid and 5 percent granular.

EPTC (Eptam); EPTC Plus Crop Protectant (Eradicane) EPTC plus crop protectant plus extender (Eradicane Extra) - Stauffer

Use--EPTC: Control of annual grasses, nutsedge and some broadleafs in sugarbeets, potatoes, seedling alfalfa, birdsfoot trefoil, clovers, sunflowers, flax, and dry edible beans except adzuki beans. EPTC can be mixed with trifluralin (Treflan) on dry beans. "Eradicane" or "Eradicane Extra" can be used in corn, especially for nutsedge, wild proso millet; gives some quackgrass control. Eradicane can be used in mixtures or as a three-way combination with atrazine and cyanazine on corn and Eptam may be mixed with trifluralin on dry beans and sunflowers, and with chloramben on sunflowers.

Rate of application--EPTC: 2 to 3 pounds per acre on sugarbeets spring applications or 4 to 4-1/2 pounds per acre for fall applications; 3 pounds per acre on seedling legumes, sunflowers, flax (fall application only) and dry edible beans; Eradicane or Eradicane Extra: 3 to 6 pounds per acre in corn.

Time of application--Preplanting in spring or previous fall.

Remarks--Must be incorporated immediately to avoid loss of chemical by volatility. Eradicane and Eptam can be applied with dry bulk and liquid fertilizers or through center pivot irrigation. Perennial grasses must be turned under and chopped thoroughly prior to treatment. Effectiveness declines with repeated annual use due to more rapid degradation by soil microorganisms.

Formulation--Eptam: 7 pounds per gallon liquid; 10 percent granular; Eradicane: 6.7 pounds per gallon liquid; Eradicane Extra: 6 pounds per gallon liquid.

Ethafluralin (Sonalan) - Elanco

Use--Annual grass, pigweed, common lambsquarters control and partial control of eastern black nightshade in soybeans. Can be tank mixed with alachlor, chloramben, metolachlor or metribuzin.

Rate of application--0.56 to 1.12 pounds per acre.

Time of application--Preplanting incorporation.

Remarks--Must be incorporated in the soil. Do not graze or feed forage.

Formulation--3 pounds per gallon liquid.

TCA - Hopkins

Use--Control of annual grasses except wild oat in sugarbeets.

Rate of application--5 to 7 pounds per acre.

Time of application--Preemergence.

Formulation--4.76 pounds per gallon liquid.

Ethofumesate (Norton) - Fisons

Use--Control of some annual broadleafs and grassy weeds in sugarbeets. Use in mixtures with TCA or as a preemergence application following fall application of EPTC.

Rate of application--1.12 to 3.75 pounds per acre.

Time of application--Preplanting, preemergence, or postemergence.

Remarks--Incorporation has improved weed control. Soil residues may affect wheat, barley, and oats the following year. Sugarbeet injury may occur, especially on coarse-textured soils if used in combination with cycloate or EPTC, or if used postemergence in combination with desmedipham and phenmedipham.

Formulation--1-1/2 pounds per gallon liquid and 4 pounds per gallon dispersible liquid.

Fluazifop (Fusilade) - ICI

Use--Control of grassy annual and perennial weeds in soybeans. Can be tank mixed with acifluorfen (Blazer).

Rate of application--1/8 to 1/2 pounds per acre.

Time of application--Early postemergence when grass weeds are 2 to 8 inches tall.

Remarks--Fluazifop has given excellent control of most annual grasses including volunteer corn, foxtails, wild proso millet and woolly cupgrass in soybeans. The chemical also controls perennial grasses. Always add a surfactant or a crop oil concentrate. Avoid spray drift onto corn.

Formulation--4 pounds per gallon liquid.

Glyphosate (Roundup) - Monsanto

Use--Non-selective control of many annual and perennial weeds before planting alfalfa, edible beans, peas, barley, corn, forage legumes and grasses, oats, potatoes, sorghum, soybeans, sugarbeets, wheat, and many vegetable crops. Spot treatment of weeds in these same crops after crop emergence, but crop will be killed or severely injured. May also be used in minimum tillage systems as tank mixtures with alachlor, metolachlor, atrazine, linuron, simazine, metribuzin, and cyanazine.

Rate of application--3/4 to 3 pounds per acre depending on time of application and weed species (see label).

Time of application--In the fall or spring before crops are planted. See label for proper timing on each weed species. Apply to actively growing foliage.

Quackgrass and wirestem muhly--when grass is at least 8 inches tall (3 or 4 leaf stage) and actively growing.

Canada thistle--bud stage in spring or before frost in fall.

Field bindweed--at or beyond full bloom.

Common milkweed--late bud to flower stage.

Can be applied with recirculating sprayers, roller or pipe-wick applicators when weeds overtop the soybeans. Volunteer corn control has been acceptable with all of these applicators.

Remarks--Take extreme care when using this product to avoid drift since most plants are susceptible to injury.

Formulation--3 pounds acid equivalent per gallon liquid.

Hexazinone (Velpar) - DuPont

Use--Weed control in established alfalfa.

Rate of application--0.45 to 1.35 pounds per acre. Use the lower rates (0.45 to 0.90 pounds per acre) on coarse textured soils low in organic matter and the

higher rates (0.90 to 1.35 pounds per acre) for medium and fine textured soils and soils high in organic matter.

Time of application--In the fall after alfalfa becomes dormant or in the spring before new growth begins.

Remarks--Treat only stands of alfalfa established for one year or more. Do not use on seedling alfalfa or on alfalfa-grass mixtures or other mixed stands. Hexazinone may injure alfalfa if excessive rates or overlaps occur. Also injury may result from the occurrence of excessive rainfall or too much irrigation water within a week or two after application.

Formulation--90 percent water soluble powder.

Linuron (Lorox) - DuPont

Use--Preemergence weed control in corn, sorghum and soybeans and directed post-emergence in corn. Used in mixtures with atrazine, alachlor, glyphosate, paraquat, or propachlor preemergence on corn and with alachlor, chloramben, metolachlor, glyphosate or paraquat preemergence on soybeans.

Rate of application--(1) Corn: 1/2 to 1-1/2 pounds per acre preemergence in combination with equal rates of atrazine active ingredient or with 3 pounds per acre of propachlor or with 1-1/2 to 3 pounds per acre of alachlor; 1-1/2 pounds per acre with wetting agent in postemergence directed spray applications. (2) Soybeans: 1/2 to 2-1/2 pounds per acre; (rate differs with soil types) or 1/2 to 1-1/2 pounds per acre with 1-1/2 to 3 pounds per acre of alachlor or pre-emergence over preplanting trifluralin.

Time of application--(1) Corn: preemergence or directed spray postemergence when corn is least 12-18 inches tall and weeds are 8 inches or less in height. (2) Soybeans: preemergence.

Remarks--Use in postemergence directed spray applications does not eliminate early season competition between weeds and corn. This early competition can reduce yields. Linuron has caused injury (stand reduction and stunting) to corn and soybeans in some Minnesota trials, particularly on sandy soils. On corn, do not apply linuron within 60 days of harvest. Reduced effectiveness of linuron if incorporated.

Formulation--50 percent wettable powder, 4 pounds per gallon dispersible liquid.

MCPA (Various trade names and manufacturers)

Use--Broadleaved weed control in small grains, flax, and pastures.

Rate of application--Small grains: 1/6 to 2/3 pounds per acre depending on formulation used, size and kinds of weeds, weather conditions, and stage of crop growth. Flax: 1/4 pound per acre. May be tank-mixed with dalapon on flax. Use 1/4 pound per acre of MCPA plus 3/4 pound per acre of dalapon. Grass pastures: 1/2 to 2 pounds per acre depending on weed susceptibility. See label.

Time of application--Postemergence. Small grains--two leaves to early boot; flax--2 to 6 inches. In pastures, when perennial weeds are 6 to 8 inches tall or in the rosette stage and actively growing.

Remarks--Use low rates on small grains underseeded with alfalfa.

Formulation--Liquids of various concentration.

Metolachlor (Dual) - Ciba-Geigy

Use--Control of annual grasses, pigweed, nightshade and nutsedge in corn, soybeans, dry beans and potatoes. Used in mixtures with atrazine, cyanazine, simazine, or dicamba in corn or with metribuzin, linuron, naptalam + dinoseb, chloramben, chlorpropham, trifluralin or dinoseb in soybeans. For minimum tillage corn in preplant mixtures with glyphosate, paraquat, atrazine, or simazine and for soybeans with linuron, metribuzin, glyphosate or paraquat.

Rate of application--1-1/2 to 3 pounds per acre.

Time of application--Preplanting, incorporated; preemergence; or early postemergence alone or with atrazine when weeds are in 2-leaf stage and corn is less than 5 inches tall.

Remarks--Metolachlor can be applied with fluid fertilizer or with center pivot irrigation systems.

Formulation--8 pounds per gallon liquid, 25 percent granule and Metolachlor plus atrazine (Bicep) 2-1/2 plus 2 pounds per gallon dispersible liquid.

Metribuzin (Lexone, Sencor) - DuPont, Mobay

Use--Annual weed control in soybeans. Control of certain annuals, winter annuals, and biennials in established alfalfa or alfalfa-grass mixtures. Better on broadleafs than grass. Can be used on soybeans in mixtures with alachlor, metolachlor, chloramben, glyphosate, paraquat, trifluralin, or pendimethalin.

Rate of application--Soybeans: 3/8 to 7/8 pound per acre depending on soil texture and organic matter. 1/8 to 3/4 pound per acre in mixtures. Alfalfa

(established one year or more): 3/8 to 1 pound per acre depending on soil texture and kinds of weeds present.

Time of application--Soybeans: Preplanting, preemergence or a combination of preplanting and preemergence. Alfalfa: When alfalfa is dormant, spring or fall.

Remarks--Soybeans: Early soybean stunting and leaf kill have frequently occurred with this chemical. Consult the label for restrictions and use rates on various soil types. Crop injury may occur on calcareous soils or alkaline soils with a pH over 7.5 or in conjunction with soil applied organic phosphate pesticides. Certain soybean varieties, Tracy and Altona, are susceptible to injury. Do not graze or harvest alfalfa within 28 days of treatment. Metribuzin may be applied on dry fertilizers or with liquid fertilizers.

Formulation--50 percent wettable powder, 75 percent "dry flowable granule", 4 pounds per gallon dispersible liquid.

Naptalam + 2,4-DB (Rescue) - Uniroyal

Use--Postemergence control of annual broad-leaved weeds (cocklebur, giant ragweed, volunteer sunflower, wild mustard) in soybeans. Used in combination with 2,4-DB.

Rate of application--1 to 1-1/2 pounds per acre of naptalam plus 1/32 to 3/64 pound per acre of 2,4-DB. Use a nonionic surfactant with the mixture.

Time of application--When soybeans are about 18 inches tall (7-10 days before bloom through mid-bloom).

Remarks--This treatment is primarily to control large (12 inch) broadleaved weeds that have escaped earlier control. There is risk of soybean injury. Do not apply to drought stressed soybeans. Rain within 6 hours after application will reduce effectivenes.

Formulation--2 pounds per gallon liquid.

Naptalam + dinoseb (Dyanap) - Uniroyal

Use--Preemergence and postemergence control of some annual broadleafs and grasses in soybeans. May be used alone, with alachlor (Lasso) or metolachlor preemergence.

Rate of application--Preemergence: 2 to 4 pounds of naptalam plus 1 to 2 pounds of dinoseb per acre alone or with 2 pounds of alachlor. Rates vary with soil type. Postemergence: 1/2 to 1 pound of naptalam plus 1 to 2 pounds of dinoseb per acre.

Time of application--Preemergence up to emergence of soybeans when used alone or preemergence with alachlor or metolachlor. Postemergence after soybeans have the second trifoliolate leaf up to when soybeans are 20 inches tall.

Remarks--Preemergence application may cause crop injury, especially if heavy rains occur or on sandy soils. Postemergence treatment may injure crop when temperatures are high or if improperly applied. Follow application and rate instructions on the labels.

Formulation--2 pounds naptalam and 1 pound dinoseb per gallon liquid.

Paraquat (Paraquat Plus, Gramoxone) - Chevron, ICI

Use--Paraquat is a contact herbicide for killing vegetation before planting or before crops emerge, and as a desiccant for weeds in soybeans and sunflowers (oil seed varieties only). A special local needs registration is also available in Minnesota for postharvest desiccation of Kentucky bluegrass fields to facilitate burning.

Rate of application--1/8 to 1 pound per acre depending on use and crop. Use X-77 spreader with paraquat.

Time of application--Apply paraquat before planting or before the crop emerges for seedling weed control in minimum and no-till cropping situations. As a preharvest desiccant, paraquat is applied after the crop is physiologically mature. In soybeans, application should be made when the beans are fully developed, at least 1/2 of the leaves have dropped, and the leaves left on the plant are turning yellow or when the soybean seeds are at 30 percent moisture or less. In sunflowers, application should be made when the seed is at 35 percent moisture or less. Sunflower head color is no longer considered a good indicator of maturity.

Remarks--Paraquat kills growing annual weed seedlings, but only the top growth of perennials. Paraquat is highly toxic and has a "restricted use" classification (can be applied only by a certified applicator). A small amount could be fatal if swallowed. Avoid contact with the eyes or skin and do not breathe the spray mist. Follow precautions on the label.

Formulation--2 pounds per gallon liquid.

Pendimethalin (Prowl) - American Cyanamid

Use--Preemergence control of annual grasses and some annual broadleaved weeds in corn. Can use alone or in a mixture with atrazine, cyanazine (Bladex), or dicamba (Banvel) for broader spectrum weed control in corn. Preplanting incorporated in soybeans alone or in mixtures with metribuzin, alachlor, chloramben, and metolachlor. Preplanting incorporated alone or with chloramben on sunflowers.

Rate of application--1/2 to 2 pounds per acre for corn; 1/2 to 1-1/2 pounds per acre for soybeans; 1/2 to 1-1/2 pounds per acre for sunflowers.

Time of application--Preemergence or early postemergence, up to 2-leaf stage of corn and weeds up to 1 inch tall, with atrazine or cyanazine in corn; preplanting in soybeans; pendimethalin alone or mixed with atrazine may be applied postemergence incorporated on corn from 4 inches tall to last cultivation; preplant incorporated on sunflowers.

Remarks--Do not use on soils containing less than 1-1/2 percent organic matter, nor on peat or muck. There is crop injury potential on soils with lower organic matter and sandy soils. Weed control has not been consistent on clay soils, peat and muck. Do not drag corn fields before crop emerges and do not incorporate on corn fields. On soybeans and sunflowers, incorporate 1 to 2 inches deep. Can be used with liquid fertilizer.

Formulation--4 pounds per gallon liquid.

Picloram (Tordon) - Dow

Use--One formulation (Tordon 22K) is cleared for use in a tank-mix combination with 2,4-D amine or ester or MCPA amine to improve control of wild buckwheat in spring and winter wheat and barley. All formulations may be used on noncropland, except do not use near rivers, lakes or other water supplies. Two formulations (Tordon 22K and Tordon 2K) may be used on grass pastures in Minnesota on a special local need label.

Rate of application--A tank-mix combination of 1/4 ounce picloram (1 fluid ounce of Tordon 22K) and 1/4 pound 2,4-D amine or ester or MCPA amine for wheat and barley, 1/2 to 2 pounds per acre in grass pastures.

Time of application--Postermergence, when wheat or barley is in the 4- to 6-leaf stage and weeds are small; postemergence in grass pastures when perennial broadleaf weeds are 6 to 8 inches tall but before bloom.

Remarks--A higher rate of application, 3/8 ounce per acre of picloram and 3/8 pound per acre of 2,4-D amine or ester or MCPA amine is cleared for use in the same crops when weeds are more advanced or under dry conditions. This higher rate may be applied from the 6-leaf stage to early boot stage. Apply picloram only on small grain fields that will be fallowed or replanted to a grass or grain crop the following year. Do not use on small grain to be underseeded to a legume. Do not use on sandy soils where ground water level is within 10 feet of the soil surface. Picloram is a restricted use pesticide and can be applied only by a certified applicator. Adhere to all label requirements for safe use of this herbicide.

Formulation--(Tordon 22K) 2 pounds per gallon liquid.

Propachlor (Ramrod) - Monsanto

Use--Annual grass control in soybeans grown for seed, corn, and grain sorghum. Used in mixtures with atrazine or cyanazine or linuron on corn and with atrazine, cyanazine, or propazine on sorghum.

Rate of application--3 to 6 pounds per acre.

Time of application--Preemergence.

Remarks--Propachlor is cleared to use on corn for grain, seed or forage, but on soybeans for seed only. Do not use propachlor-treated soybeans for food, feed, or oil. Can be used with liquid fertilizer.

Formulation--20 percent granular, 4 pounds per gallon dispersible liquid, or Ramrod/atrazine, 3 + 1 pounds per gallon dispersible liquid.

Propanil (Stampede) - Rohm and Haas

Use--Control of green and yellow foxtail and specific broadleaf weeds in hard red spring wheat, durum wheat, and spring barley.

Rate of application--1-1/8 to 1-1/2 pounds per acre alone or 1-1/8 pounds per acre in combination with 1/4 pound per acre of an iso-octyl ester formulation of MCPA.

Time of application--Postemergence when a majority of the foxtail is in the 2- to 4-leaf stage. Use higher rate on 4-leaf grasses and more tolerant broadleafs.

Remarks--Do not apply propanil beyond the 5 leaf stage of HRS wheat or at rates of more than 1-1/2 pounds per acre or beyond the four leaf stage of durum wheat or rates higher than 1.13 pounds per acre, or severe injury to the crop may result. Do not tank mix with herbicides other than MCPA iso-octyl ester formulations. Do not apply Stampede to wheat that has been treated with soil applied systemic insecticides such as Furadan, Thimet or Disyston within the past year. Do not graze treated crop or cut for green chop feed. Do not apply if frost is expected within 24 hours or when temperatures are above 85 degrees F, especially with drying winds.

Formulation--3 pounds per gallon liquid.

Pronamide (Kerb) - Rohm and Haas

Use--Annual and perennial grass control in pure stands of alfalfa, clover, birdsfoot trefoil, or crown vetch.

Rate of application--1 to 2 pounds per acre.

Time of application--Fall when soil temperatures are below 60 degrees F. but before freeze-up.

Remarks--Do not graze or harvest alfalfa within 25 to 45 days depending on the rate of application or other crops for 120 days after application. Use only on established legume plantings or on new plantings after the legume has reached the trifoliolate leaf stage.

Formulation--50 percent wettable powder.

Propazine (Milogard)- Ciba-Geigy

Use--Control of annual grasses and broadleaved weeds in grain sorghum. Used in mixtures with propachlor on grain sorghum.

Rate of application--0.8 to 2 pounds per acre.

Time of application--Preemergence.

Remarks--Corn may be planted in rotation 12 months after treatment. Other crops should not be planted for 18 months following treatment. Do not use in sand or loamy sand soils.

Formulation--80 percent wettable powder.

Pyrazon (Pyramin) - BASF

Use--Control of most annual broadleafs in sugarbeets. Has been more effective on medium to coarse textured soils with less than 5 percent organic matter. May be applied preemergence with TCA.

Rate of application--3.8 to 7.6 pounds per acre.

Time of application--Preemergence or preplanting incorprated; postemergence when sugarbeets have two expanded true leaves and before weeds have more than 2 to 4 true leaves.

Remarks--A rain shortly after application is necessary for best results. Incorporation usually improves weed control. Do not use on sands or loamy sands as crop injury may occur; do not use preemergence on peat or muck soils.

Formulation--75.5 percent wettable powder or 4.2 pounds per gallon dispersible liquid.

Sethoxydim (Poast) - BASF

Use--Control of grassy weeds in soybeans. Mixtures with bentazon or bentazon plus acifluorfen are labeled. Increase sethoxydim rate 50% in mixtures.

Rate of application--0.1 to 0.5 pounds per acre. High rate for perennial grasses.

Time of application--Postemergence.

Remarks--Sethoxydim gives excellent control of most annual grassy weeds including volunteer corn, foxtails, wild proso millet and wooly cupgrass in soybeans. In addition, sethoxydim gives food suppression or control of several perennial grass weeds such as quackgrass and wirestem muhly. An oil concentrate is used with the spray mixture. Avoid spray drift onto corn.

Formulation--1.53 pounds per gallon liquid.

Simazine (Princep) - Ciba-Geigy

Use--Control of grasses and broadleaved weeds in alfalfa, birdsfoot trefoil for seed, and corn.

Rate of application--0.8 to 1.6 pounds per acre on alfalfa and birdsfoot trefoil; 2 to 4 pounds per acre on corn.

Time of application--On established alfalfa, after last cutting in the fall and before the ground is frozen. Preplanting or preemergence on corn. Fall or spring on well established, dormant birdsfoot trefoil.

Remarks--Residues in the soil may injure susceptible crops planted the following year.

Formulation--80 percent wettable powder, 4 pounds per gallon liquid and 90 percent water dispersible granules.

Terbacil (Sinbar) - DuPont

Use--Control of several annual broadleaf and grass weeds in alfalfa that has been established for one or more years. Treatment will not control established perennial weeds.

Rate of application--0.4 to 1.2 pounds per acre depending upon weed species to be controlled and on soil type and organic matter percentage. Use lower rate on course-textured soils with less than 2 percent organic matter.

Time of application--In the fall after alfalfa plants become dormant or in the spring before new growth starts.

Remarks--Do not use on seedling alfalfa or on alfalfa-grass mixtures or other mixed stands. Do not apply on established stands after new growth starts in the spring. Do not replant treated areas to any crop within two years after last application as injury to subsequent crops may result. There is potential for alfalfa injury, especially on sandy soils or soils low in organic matter.

Formulation--80 percent wettable powder.

Triallate (Far-go, Avadex-BW) - Monsanto

Use--Control of wild oat in spring and durum wheat and barley, peas and lentils.

Rate of application--1 to 1-1/4 pounds per acre on wheat; 1-1/4 to 1-1/2 pounds per acre on barley. Lower rates are for liquid formulation and higher rates are for granular formulation.

Time of application--Postseeding (preemergence) for wheat; preplanting or postseeding for barley (postseeding preferred). Fall incorporated or surface applications are possibilities. See label for details.

Remarks--Must be incorporated by two harrowings at right angles for postseeding applications. Incorporate preplanting applications as described previously for diallate. In postseeding applications, seed crop to a depth of 2 to 3 inches. Do not aply to a field in a ridged condition. Do not plant domestic oats where triallate was used the previous year. May be tank-mixed with trifluralin for spring postseeding application for wheat and barley. This chemical irritates skin and eyes; use caution when handling.

Formulation--4 pounds per gallon liquid; 10 percent granules.

Trifluralin (Treflan) - Elanco

Use--Annual grass and pigweed control in soybeans, dry edible beans including adzuki beans, sunflowers, mustard, sugarbeets, and spring wheat. Used in mixtures with chloramben, metribuzin, chlorpropham, metolachlor, alachlor, or vernolate on soybeans; with chloramben and EPTC on dry beans; and with trialate on spring wheat and barley.

Rate of application--1/2 to 1 pound per acre, depending on soil type. Use lower rates on coarse-textured soils and higher rates on finer-textured soils. On spring wheat, the rates are 1/2 to 3/4 pound per acre.

Time of application--Preplanting on soybeans, dry edible beans, mustard and sunflowers; postemergence on 2 to 6 inch sugar beets after blocking or thinning and before new weeds come up. On spring wheat and barley, apply immediately after planting or the previous fall just before freezeup.

Remarks--Must be incorporated into the soil soon after application. Proper incorporation of preplanting applications can be accomplished by disking field twice, once in each direction, immediately after applying chemical. This chemical sometimes causes slight soybean stand reduction and early soybean injury. To reduce spring wheat injury potential, plant wheat 2 to 3 inches deep, apply the chemical and incorporate shallowly with a harrow operated in two different directions. Can be applied with fluid or dry bulk fertilizer.

Formulation--4 pounds per gallon liquid; 5 percent granular.

Vernolat (Vernam, Reward) - Stauffer

Use--Controls annual grasses and some broadleafs in soybeans. Cleared for use in mixtures with trifluralin, alachlor, pendimethalin and chloramben in soybeans. Cleared for sequential (overlay) treatments with chlorpropham, linuron, bentazon, and naptalam + dinoseb.

Rate of application--2 to 3 pounds per acre.

Time of application--Preplant incorporated; incorporate immediately.

Remarks--Vernolate must be incorporated immediately after application to prevent loss by volatilization. Incorporation should be done by disking twice or by using a power rotary tiller. Early soybean injury has sometimes occurred. Can be applied with fluid or dry bulk fertilizer. Reward formulation contains an extender to increase longevity in the soil.

Formulation--7 pounds per gallon; 10 percent granular. Reward--6 pounds per gallon.

HERBICIDE NAMES

This is an alphabetical list of trade names of herbicides commonly used on cropland in Minnesota. The active ingredient(s) in these products is given across from the chemical's common name.

Trade Name	Common Name/Active Ingredient
AAtrex	atrazine
Alanap	naptalam (NPA)
Amdon 10K	picloram
Amdon 101	picloram + 2,4-D
Amiben	chloramben
Avadex	diallate
Avenge	difenzoquat
Balan	benefin
Banvel	dicamba
Banvel II	dicamba
Basagran	bentazon
Basalin	fluchloralin
Betamix	desmedipham + phenmedipham
Betanex	desmedipham
Bicep	metolachlor + atrazine
Bladex	cyanazine
Blazer	acifluorfen
Brominal	bromoxynil
Brominal Plus	bromoxynil + MCPA
Bronate	bromoxynil + MCPA
Buctril	bromoxynil
Butoxone	2,4-DB
Butyrac 200	2,4-DB
Carbyne	barban
Dow General	dinoseb
Dowpon M	dalapon
Dowpon C	dalapon + TCA
Dual	metolachlor
Dyanap	naptalam + dinoseb
Endothal	endothall
Eptam	EPTC
Eradicane	EPTC+safener
Eracicane Extra	EPTC+safener+ext.
Evik	ametryne
Far-go	triallate
Furloe	chlorpropham
Fusilade	fluazifop
Glean	chlorsulfuron
Gramoxone	paraquat
Herbicide 273	endothall

Trade Name (continued)	Common Name/Active Ingredient (cont.)
Hoelon	diclofop
Kerb	pronamide
Kleen-Krop	naptalam and dinoseb
Lasso	alachlor
Lasso II	alachlor 15% gran.
Lexone	metribuzin
Lorox	linuron
Milocep	propazine + metolachlor
Milogard	propazine
Modown	bifenox
MonDak	dicamba and MCPA
Nortron	ethofumesate
Paraquat	paraquat
Poast	sethoxydim
Premerge	dinoseb (DNBP)
Princep	simazine
Prowl	pendimethalin
Pyramin	pyrazon
Pyramin Plus	pyrazon and dalapon
Ramrod	propachlor
Rescue	naptalam + 2,4-DB
RewardI	vernolate + ext.
Ro-Neet	cycloate
Roundup	glyphosate
Sencor	metribuzin
Sinbar	terbacil
Sonalan	ethalfluralin
Stampede	propanil
Sutan +	butylate + safener
Sutazine	butylate+atrazine
TCA	TCA
Tordon	picloram
Tordon 212, 101	picloram and 2,4-D
Treflan	trifluralin
Vernam	vernolate
Weedmaster	dicamba and 2,4-D

Omission of other trade names of similar herbicides is unintentional. The inclusion of a trade name does not imply endorsement and exclusion does not imply nonapproval.

SUGGESTIONS FOR CHEMICAL CONTROL OF WEEDS IN FIELD CROPS

Table 1. Suggestions for chemical control of weeds in field crops. Application rates are on a broadcast basis and refer to acid equivalent or active ingredient rather than amount of commercial product. Avoid repeated and prolonged contact with all herbicides, especially direct contact with the skin and eyes. Check label restrictions for use of crops for food or feed.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Corn	alachlor (Lasso) (Lasso II)	2 to 4 2.4 to 3.9	Preemergence or preplanting	Incorporate for nutsedge. May shallow incorporate for annual weeds.	None
	metolachlor (Dual)	1.5 to 3	Preplanting or preemergence	Incorporate for nutsedge. May shallow incorporate for annual weeds.	None
	atrazine	1 to 3	Preplanting, preemergence or early postemergence	Atrazine may injure crops the following year	Do not graze or feed forage for 21 days after treatment
	EPTC with protectant (Eradicane) or EPTC+ protectant + extender (Eradicane Extra)	3 to 6	Preplanting incorporation	Do not use on corn seed stock.	None
	butylate (Sutan +, Genate Plus)	4 to 6	Preplanting incorporation	Do not use on corn seed stock (Breeders, Foundation, Increase)	None
	propachlor (Ramrod)	4 to 6	Preemergence		None
	cyanazine (Bladex)	1.25 to 4.75	Preplanting Preemergence Early postemergence (80 W or 90 DF only).	Do not use on sandy soils. Use oil or surfactant postemergence under arid conditions only.	None
	atrazine and alachlor	1 to 2+ 1½ to 2½	Preplanting or preemergence		Do not graze or feed forage for 21 days after treatment.
	atrazine and metolachior (Bicep or tank mix)	1 to 3+ 1¼ to 3	Preplanting or preemergence		
	cyanazine and alachlor	0.6 to 3 2 to 2½	Preplanting or preemergence	Do not use on sandy soils.	None
	cyanazine and metolachior	0.6 to 3 1.25 to 2.5	Preplanting or preemergence	Do not use on sand or on loamy sand with less than 1% organic matter.	None
	dicamba (Banvel) + alachlor	½ + 2 to 2½	Preemergence	Use only on medium or fine textured soils with more than 3% organic matter.	Do not graze or feed silage prior to milk stage.
	dicamba and metolachlor	½ + 2 to 2½	Preemergence	Use only on medium or fine textured soils with more than 2.5% organic matter	Do not graze or feed silage prior to milk stage.
	attrazine and butylate (Sutazine or tank mix)	1 to 1½ +3 to 4	Preplanting incorporation	Do not use on corn seedstock (Breeders, Foundation, Increase)	Do not graze or feed forage for 21 days after treatment.
	cyanazine and butylate	0.6 to 3 + 3 to 4	Preplanting or incorporation		None
	atrazine and EPTC (Eradicane, Eradicane Extra)	1 to 1½ + 3 to 4	Preplanting incorporation	Do not use on corn seedstock.	None
	cyanazine and EPTC (Eradicane)	0.6 to 3 + 3 to 4	Preplanting incorporation	Do not use on corn seedstock.	None
	atrazine and propachlor	1 to 1½ + 2 to 3¾	Preemergence		None

Table 1. (continued) Suggestions for chemical control of weeds in field crops.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Corn	linuron (Lorox) and alachlor	½ to 1½ + 1 to 3	Preemergence	Do not use on sandy soils.	Do not graze or harvest immature corn for feed within 12 weeks after treatment. Linuron is a restricted use pesticide.
	linuron and propachlor	1 to 1½ + 2 to 3	Preemergence	Do not use on sandy soils.	None
	pendimethalin (Prowl) and atrazine	.75 to 1.5+ 1 to 1.5	Early postemergence (spike to 2-leaf stage corn)	Apply before weeds are 1 inch tall	None
	pendimethalin and cyanazine (80W)	.75 to 1.5+ 1 to 2	Early postemergence (spike to 2-leaf stage corn)	Apply before weeds are 1 inch tall	None
	2.4-D amine 2.4-D ester	¼ to ½ 1/6 to ⅓	Corn 4 inches to tasseling	Broadleafs only. Corn most susceptible during rapid growth. Use drop nozzles after corn is 8 inches tall.	Do not forage or feed fodder for 7 days following 2.4-D application.
	2.4-D amine 2.4-D ester	½ to 1 ⅓ to ⅔	Corn over 3 feet	Spray base of stalks only	
	dicamba (Banvel) dicamba + 2.4-D amine	⅛ to ½ ⅛ to ¼	Postemergence at high rate before corn is 5 inches tall and at lower rates to within 15 days of tasseling.	See precautions on label to reduce risk of serious drift problems.	Do not graze or harvest for feed before milk stage.
	bentazon (Basagran)	¾ to 1	Weeds 2 to 6 inches	Early applications most effective	None
	bentazon + atrazine (Laddock) + oil concentrate	½ to ¾ + ½ to ¾ + 1 qt./A	Postemergence before weeds 2 to 4 inches and corn 1 to 5 leaves.	Control broadleafs only	Do not graze treated area or feed treated to livestock 21 days following application.
	bromoxynil	¼ to ½	Postemergence before weeds 6 inches and corn 14 inches.		
Alfalfa, sweetclover, and birdsfoot trefoil in flax	MCPA amine	⅛ to ¼	Not before clover is 2 inches tall	Sweetclover injured. Canopy of crop or weeds reduces injury.	None
Legume establishment without a companion crop	benefin (Balan) EPTC (Eptam)	1⅛ to 1½ 2 to 3	Preplanting incorporation	Alfalfa only	None None None
	2.4-DB amine 2.4-DB ester	½ to 1½ ½ to 1	1 to 4 trifoliolates on legumes	Sweetclover injured.	Do not graze within 60 days or cut hay within 30 days after application.
Established alfalfa	2.4-DB amine 2.4-DB ester	½ to 1½ ½ to 1	When annual weeds are 1 to 3 inches tall (2 to 5 leaves)	May injure alfalfa.	Do not graze within 60 days or cut hay within 30 days after application.
	simazine (Princep)	0.8 to 1.6	Fall	May injure alfalfa.	Do not graze for 30 days or cut hay for 60 days after treatment.
	metribuzin (Lexone, Sencor)	⅜ to 1	Fall or spring when alfalfa is dormant.	May injure alfalfa.	Do not graze or harvest within 28 days of application.
	terbacil (Sinbar)	¼ to ¾		May injure alfalfa.	Do not plant other crops within 2 years after application.
	pronamide (Kerb)	1 to 2	Fall	May injure alfalfa.	Do not graze or harvest alfalfa within 25 to 45 days after application.
	hexazinone (Velpar)	0.45 to 1.35	Fall or spring when alfalfa is dormant	May injure alfalfa.	Do not graze or feed treated forage within 30 days after application.

Table 1. (continued) Suggestions for chemical control of weeds in field crops.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Established grass pastures	2,4-D	½ to 2	Before bud stage, preferably when weeds are 2 to 6 inches tall and growing vigorously. When woody plants are fully leaved.	Rate depends on kinds of weeds. Use MCPA only at low rates, if legumes are present. Use 2,4-D, dicamba, picloram, or mixture of these for woody plant control. Avoid drift, especially of dicamba or picloram to susceptible crops, particularly soybeans and sunflowers. Read label precautions before using picloram. Picloram is a restricted use pesticide.	Do not graze dairy animals on treated areas within 7 to 14 days after application of 2,4-D. See label. Do not cut 2,4-D treated grass for hay for 30 days. Do not graze dairy animals for 7 to 21 days after application of these rates of dicamba. See label. Do not graze or feed forage for two weeks after application of picloram
	MCPA	¼ to 2			
	dicamba (Banvel)	½ to 1			
	picloram (Tordon 22K & 2K)	½ to 2			
Dry edible beans	chloramben (Amiben)	3	Preemergence		None
	EPTC (Eptam or Genep)	3	Preplant incorporation	Incorporate immediately. Do not use on adzuki beans.	None
	ethalfluralin (Sonalan)	.56 to 1.13	Preplant incorporation	Do not use on adzuki beans.	None
	trifluralin (Treflan)	½ to 1	Preplant incorporation		None
	pendimethalin (Prowl)	½ to 1½	Preplant incorporation	Do not use on adzuki beans.	None
	alachlor (Lasso)	2½ to 3	Preplant incorporation	Do not use on adzuki beans.	None
	metolachlor (Dual)	1½ to 3	Preplant incorporation or Preemergence	Do not use on adzuki beans.	None
	bentazon (Basagran)	¾ to 1	Postemergence	Beans in first trifoliolate, weeds less than 2 inches and 4 true leaves.	None
Sugarbeets	TCA	5 to 7	Preemergence	For grass weeds except wild oat.	Do not use treated tops for food or feed.
	pyrazon (Pyramin) + TCA	3.8 to 7.6 + 5 to 7	Preemergence or preplant incorporation	Has been less effective on soils with more than 5% organic matter.	None
	dalapon	2 to 3 2½ to 3½	Beets up to 6-leaf stage.	For grass weeds except wild oat.	None
	diallate (Avadex)	1½ to 2	Directed, beets 7-leaf stage to 14 inches Preplanting incorporation	For wild oat. Spring or fall application.	Do not graze unharvested crop.
	barban (Carbyne)	⅔ to 1	Wild oat in two-leaf stage	For wild oat.	Do not allow livestock to graze treated fields until after crop is harvested.
	desmedipham + phenmedipham (Betamix)	0.365 to 0.6 + 0.365 to 0.6	Early postemergence		Do not apply within 90 days of harvest.
	desmedipham (Betanex)	1 to 1¼	Early postemergence		
	endothall (Herbicide 273)	¾ to 1½	Early postemergence	For wild buckwheat and annual smartweed.	None
	EPTC (Eptam)	2 to 3 — spring 4 to 4.5 — fall	Preplanting incorporation	For grass and some broadleaved weeds.	None
	ethofumesate (Nortron)	2 to 3¾	Preplanting incorporation		None
	cycloate (Ro-neet)	3 to 4	Preplanting incorporation in spring or fall	For grass weeds and some annual broadleafs. Similar performance to EPTC but less injury.	None
	diethatyl (Antor)	4 to 6	Preplanting incorporation	For pigweed and some annual grasses	None

Table 1. (continued) Suggestions for chemical control of weeds in field crops.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Sugarbeets	ethofumesate (Nortron)+ desmedipham (Betanex)	1.12 to 1.5 + 0.73 to 1.0	Postemergence, beets with 6 leaves or larger	Improved weed control and more sugarbeet injury than from desmedipham or desmedipham-phenmedipham.	Do not apply these combinations to crops previously treated with ethofumesate.
	ethofumesate (Nortron)+ desmedipham + phenmedipham	1.12 to 1.5+ 0.365 to 0.5+ 0.365 to 0.5			
Soybeans	acifluorfen (Blazer)	⅜ to ½	Early postemergence (soybeans in first trifoliolate, weeds less than 2 inches tall and 4 true leaves)	Controls many annual broadleafs, including black nightshade.	Do not graze or use soybean hay or forage.
	alachlor (Lasso)	2 to 4	Preplant incorporation or preemergence	Incorporate for nutsedge control	None
	chloramben (Amiben)	3	Preplant incorporation or preemergence	May shallow incorporate for annual weeds.	None
	chlorpropham (Furloe Chloro IPC)	2 to 3	Preplant incorporation or preemergence	For smartweed control	None
	diciofop (Hoelon)	¾ to 1¼	Early postemergence when soybeans are between the first and sixth trifoliolate leaf stage, before annual grasses exceed 4 leaves before volunteer corn exceeds 10 inches	Controls many annual grasses, and volunteer corn.	Do not graze or use soybean hay or forage. Diclofop is a restricted use pesticide.
	linuron (Lorox)	½ to 2½	Preemergence	Increased soybean injury potential at high use rates. Use in combinations at lowered use rates. Do not use on soils with organic matter above 5 percent or below ½ percent.	None
	metolachlor (Dual)	1½ to 3	Preplant incorporation or preemergence	Incorporate for nutsedge control	Do not graze or feed soybean hay or forage.
	metribuzin (Sencor Lexone)	¼ to ¾	Preplant incorporation or preemergence	Increased soybean injury potential at high use rates. Use in combinations at lowered use rates. See label for soil restrictions. Soybean injury may occur on alkaline soils, sandy soils or where atrazine residues are present.	None
	pendimethalin (Prowl)	½ to 1½	Preplant incorporation		None
	trifluralin (Treflan)	½ to 1	Preplant incorporation		None
	vernolate (Vernam)	2 to 3	Preplant incorporation		None
	bentazon (Basagran)	¾ to 1½	Early postemergence (soybeans in first trifoliolate, weeds less than 2 inches and 4 true leaves)	Controls most annual broadleafs, Canada thistle, nutsedge.	None
	ethal fluralin (Sonalan)	0.56 to 1.3	Preplant incorporation	Partial control of eastern black nightshade	Do not graze or feed forage.

Table 1. (continued) Suggestions for chemical control of weeds in field crops.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Soybeans	2,4-DB amine	1/5	Postemergence directed	For cocklebur control	Do not harvest within 60 days after application.
Winter wheat	2,4-D amine 2,4-D ester MCPA	¼ to ¾ ¼ to ½ ¼ to ¾	Wheat fully tillered to boot stage.	For broadleafs	Do not graze or feed forage from 2,4-D treated fields within 2 weeks after treatment. None for MCPA.
	dicamba + MCPA amine dicamba +2,4-D amine	⅛ + ¼ to ⅜ ⅛ + ¼ to ⅜	After winter dormancy until wheat begins to joint.	For broadleafs	Do not graze dicamba treated field or harvest for dairy feed prior to crop maturity.
	bromoxynil bromoxynil + MCPA ester	¼ to ½ ¼ to ¼	Wheat fully tillered to boot stage	For broadleafs	Do not forage or graze for 30 days after treatment with bromoxynil.
	diclofop (Hoelon)	¾ to 1 ¼ (wheat) ¾ to 1 (barley)	1 to 4 leaf stage of grass weeds (wheat) 1 to 3 leaf stage of grass weeds (barley)	For annual grass weeds including wild oat. Use high rate for larger weeds. Do not apply other herbicides within one week of diclofop application.	Do not graze treated areas or harvest forage from treated fields prior to grain harvest. Diclofop is a restricted use pesticide.
	picloram and 2,4-D amine	1/64 to 3/128 + ¼ to ⅜	4-leaf to early boot	May persist in the soil to harm most broadleaf crops. Use only where grass or grain crop will be planted the following year.	Picloram is a restricted use pesticide.
Rye	2,4-D amine 2,4-D ester MCPA amine or ester	¼ to ¾ ¼ to ½ ¼ to ¾	Rye fully tillered to boot stage		Do not graze or feed forage from 2,4-D treated fields for 2 weeks after treatment. None for MCPA.
Spring wheat	propanil	1⅛ to 1½	3 to 5 leaf stage of wheat	For annual grasses and certain broadleafs. May cause temporary leaf injury or a slight delay in maturity.	Do not graze treated crop or cut for green chop feed.
	propanil + MCPA iso-octyl ester	1⅛ + ¼	2 to 4 leaf stage of grass weeds	Do not use on fields previously treated or to be treated this year with organo-phosphorus or carbamate insecticides.	
Spring wheat or barley	2,4-D amine 2,4-D ester	¼ to ⅔ 1/6 to ½	Fifth leaf to early boot	Amine less injurious to crop. May injure legumes.	Do not forage or graze for 2 weeks after treatment.
	MCPA amine MCPA ester	¼ to ⅔ 1/6 to ½	Two leaf to early boot	May injure legumes.	None
	trifluralin (Treflan)	½ to ¾	Postplanting incorporation in spring or preplanting incorporated in fall prior to spring seeding.	Improper application may result in crop injury. May be tank-mixed with triallate in spring, not in fall.	None
	Chlorsulfuron (Glean)	1/96 to 1/32	Preemergence or Postemergence	For broadleafs and grasses. Follow label directions to avoid carry-over injury to sensitive crops.	

Table 1. (continued) Suggestions for chemical control of weeds in field crops.

Crop	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Spring wheat or barley	bromoxynil and MCPA esters	¼ + ¼	Two leaf to early boot	Use for smartweeds or wild buckwheat. Do not use on underseeded legumes.	Do not forage or graze for 30 days after treatment.
	bromoxynil (Brominal, Buctril)	¼ to ½	Two leaf to early boot		
	diclofop	¾ to 1¼ (wheat)	1 to 4 leaf stage of grass weeds (wheat)	For annual grass weeds including wild oat. Use high rate for larger weeds. Do not apply other herbicides within one week of diclofop application.	Do not graze treated areas or harvest forage from treated fields prior to grain harvest. Diclofop is a restricted use herbicide.
		¾ to 1 (barley)	1 to 3 leaf stage of grass weeds (barley)		
	picloram and 2,4-D amine	1/64 to 3/128 + ¼ to ⅜	4-leaf to early boot	May persist in the soil to harm most broadleaf crops. Use only where grass or grain crop will be planted the following year.	Picloram is a restricted use pesticide.
Spring wheat or oats	dicamba and MCPA amine	⅛ + ¼	Two to five-leaf stage	Kills legumes. Use if weeds include smartweeds or wild buckwheat.	Do not graze treated areas or harvest for dairy feed prior to crop maturity.
Oats	2,4-D amine	¼ to ½	Sixth leaf to early boot	MCPA less injurious to crop.	Do not forage or graze for 2 weeks after treatment.
	MCPA amine	¼ to ⅔	Two leaf to early boot	Bromoxynil for smartweed and wild buckwheat.	None
	MCPA ester	1/6 to ½			None
	bromoxynil	¼ to ⅜			Do not forage or graze for 30 days after treatment.
Flax	MCPA	¼	Flax 2 to 6 inches	Mixture of MCPA amine with dalapon for broadleaved and grass weeds.	None
	dalapon	¾	Flax 2 to 6 inces		None
	EPTC (Eptam)	2 to 3	Preplanting incorporation	Fall application only	None
	bromoxynil	¼ to ½	Flax 2 to 8 inches	For smartweed, wild buckwheat in 2 to 4 leaf stage.	Do not graze for 30 days after treatment.
	trifluralin	½ to 1	Preplanting incorporation	Fall application only For annual grasses	None
Alfalfa and clover in small grains	Some fomulations of 2,4-D amine or MCPA amine (See label)	⅛ to ¼	Not before clover is 2 inches tall	Injures legumes. Canopy of crop or weeds reduces injury. Do not use on sweetclover.	Do not graze dairy animals on treated areas within 7 days after application of 2,4-D.
Sunflowers	chloramben (Amiben)	2 to 3	Preemergence		Do not graze or feed forage.
	alachlor	2 to 4	Preplanting incorporation or preemergence		None
	EPTC (Eptam)	2 to 3	Preplanting incorporation	Fall or Spring Application	None
	trifluralin (Treflan)	½ to 1	Preplanting incorporation		None
	pendimethalin (Prowl)	½ to 1½	Preplanting incorporation		Do not feed treated forage to livestock.
	pendimethalin + chloramben	¾ to 1¼ + 2	Preplanting incorporation		Do not feed treated forage to livestock.
	trifluralin + EPTC	½ to 1 + 2	Preplanting incorporation		None
	EPTC + Chloramben	2 to 3 + 1 to 2	Preplanting incorporation		Do not graze or feed forage.

Table 2. (continued) Suggestions for chemical control of weeds on cropland. Follow label precautions carefully.

Weed	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Canada and sowthistle	2,4-D amine	½	Just before bud	Can spray in tolerant crops.	See crop
	2,4-D ester	1	Fall rosette	Plow or clip in fall and spray when 6 inches.	See crop
	dicamba (Banvel)	⅛ to ¼		See crop discussion. Drift may affect sensitive crops. Use for patch treatment of 2,4-D-resistant thistles.	See discussion sections on oats, wheat, corn, and pastures.
	glyphosate (Roundup)	1½	Bud stage or in fall before frost	May be used before planting or for spot treatment in barley, corn, oats, sorghum, soybeans, wheat (kills crop)	Do not feed or forage subsequently grown crop for 8 weeks after application.
	bentazon (Basagran)	¾ to 1 each time if two applications or 1 to 1½ if one application	8 to 12-inch thistles Repeat 7 to 10 days later. 8 to 12-inch thistles	For soybeans or corn. Split applications usually better than one.	See crop
Field bindweed	2,4-D ester	1	Late fall	Re-treat second year.	See crop
	2,4-D amine	½	Bud to bloom		See crop
	glyphosate (Roundup)	2¼ to 3¾	Full bloom to frost	May be used before planting or for spot treatment in barley, corn, oats, sorghum, soybeans, wheat (kills crops)	Do not feed or forage subsequently grown crop for 8 weeks after application.
Germander, field mint	atrazine + oil	2	Early postemergence	For corn	See crop
	EPTC (Eradicane)	4 to 6	Preplanting, incorporated	For corn	See crop
Jerusalem artichoke	2,4-D	⅜ to ½	6-inch artichoke. Repeat when regrowth reaches 6 to 8 inches.	Use during crop tolerant periods in corn, small grains, pastures.	See crop
Leafy spurge	2,4-D ester	2 to 3	Bud	After grain harvest or on grass pastures. Re-treat growth when 4 to 6 inches.	See crop
	2,4-D ester	½	Bud	In corn, wheat, or barley. Cultivate after harvest until freezeup.	See crop
Yellow nutsedge	metolachlor (Dual)	3	Preplanting, incorporated	For corn, soybeans	See crop
	alachlor (Lasso)	4		For corn, soybeans	See crop
		3		For dry beans	See crop
	butylate (Sutan +)	4 to 6		For corn	See crop
	EPTC (Eptam)	3		For dry beans, sugarbeets, sunflowers	See crop
	EPTC + protectant (Eradicane)	4 to 6		For corn	See crop
	vernolate (Vernam)	3		For soybeans	See crop
	atrazine + oil	2	Postemergence after a preplanting treatment when nutsedge is less than 3 inches tall.	For corn	See crop

Table 2. (continued) Suggestions for chemical control of weeds on cropland. Follow label precautions carefully.

Weed	Chemicals	Pounds per acre of active ingredient or acid equivalent broadcast	Time	Remarks	EPA registration limitations on crop use
Yellow Nutsedge	bentazon (Basagran)	¾ to 1	6 to 8-inch nutsedge. Repeat 7 to 10 days later.	For soybeans or corn. Split applications usually better.	See crop
Quackgrass	dalapon (Dowpon)	11	Fall	Foilage application, plow 1 or 2 weeks later. May plant corn, dry beans, some varieties of potatoes, sugarbeets next spring.	Do not graze treated areas in year treated.
	EPTC (Eradicane)	6	Preplanting incorporation	For more consistent control, apply glyphosate or atrazine in the fall followed by EPTC in the Spring.	
Quackgrass Wirestem muhly (muhlenbergia)	atrazine	2 to 4	Spring or fall. Split application in fall and spring preferred.	Use low rate on sandy soils. Only corn can be grown the year after treatment.	See corn.
	glyphosate (Roundup)	¾ to 1½	Fall or Spring before plowing or for spot treatment in crop (kills crop)	Quackgrass should be at least 8 inches tall (3 to 4 leaf stage) and actively growing.	Do not feed or graze treated crops within 8 weeks after application.
Wild oat	barban (Carbyne)	¼ to ⅜	When wild oat is in two-leaf stage. Before 4-leaf stage of spring small grains, before 12-leaf stage of flax, within 30 days after emergence of sugarbeet, sunflower, mustard, soybean.	Rate for wheat, barley, flax. Two applications may be made.	Do not allow livestock to graze treated fields until after crop is harvested. Do not feed soybean forage or flax straw from treated fields.
	barban (Carbyne)	⅜		Rate for semidwarf wheat varieties, sunflower, mustard, soybeans.	
	barban (Carbyne)	¾ to 1		Rate for sugarbeets.	
	diallate (Avadex)	1½ to 2 (liquid)	Preplanting or preemergence, fall or spring	Rate for flax and sugarbeets; must be incorporated into soil.	None
	diallate (Avadex)	1½		Rate for corn	
	triallate (Far-go)	1 to 1¼ (wheat) 1¼ to 1½ (barley)	Preplanting or preemergence fall or spring.	Must be incorporated into into soil, except late fall granules.	Do not graze livestock on treated areas. May be tank-mixed with trifluralin or wheat or barley.
	difenzoquat (Avenge)	⅝ to 1	When wild oat has 3 to 5 leaves.	For barley, winter wheat and the spring and durum wheat varieties listed on the label.	Do not graze treated fields or cut for silage. Grain and straw can be fed.
	diclofop (Hoelon)	¾ to 1¼	When grass weeds have 1 to 4 leaves. Use higher rates for larger weeds.		Do not graze treated areas or cut for forage prior to grain harvest. Diclofop is a restricted use pesticide.

Effectiveness of herbicides on weeds in corn[1]

	Preplanting +						Preemergence								Postemergence						
	Alachlor (Lasso)	Metolachlor (Dual)	Butylate (Sutan + Genate Plus)	EPTC (Eradicane, Eradicane Extra)	Cyanazine (Bladex)	Atrazine (AAtrex, others)	Alachlor (Lasso)	Atrazine (AAtrex, others)	Dicamba (Banvel)	Metolachlor (Dual)	Pendimethalin (Prowl)	Propachlor (Ramrod, Bexton)	Linuron (Lorox)	Cyanazine (Bladex)	2,4-D	Dicamba (Banvel)	Atrazine and oil	Cyanazine (Bladex)	Bentazon (Basagran)	Pendimethalin (Prowl)	Bromoxynil (Brominal, Buctril)
Corn tolerance—	G	G	G	G	F	G	G	G	F	G	F	G	F	F	F	G	G	F	G	F	G
Grasses—																					
Giant & robust foxtail	G	G	G	G	F	F	G	F	P	G	F	G	F	F	N	N	F	F	N	F	N
Green foxtail	G	G	G	G	G	G	G	G	P	G	F	G	F	G	N	N	G	G	N	F	N
Yellow foxtail	G	G	G	G	G	G	G	G	P	G	F	G	F	G	N	N	G	G	N	F	N
Barnyardgrass	G	G	G	G	F	F	G	F	P	G	F	F	F	F	N	N	F	F	N	F	N
Crabgrass	G	G	G	G	F	P	G	P	P	G	F	G	G	F	N	N	P	F	N	F	N
Panicum	G	G	G	G	F	P	G	P	P	G	F	F	G	F	N	N	P	F	N	F	N
Nutsedge	G	G	G	G	P	P	F	P	N	F	N	F	P	P	N	N	F	P	G	N	N
Quackgrass	N	N	N	F	P	G	N	G	N	N	N	N	N	P	N	N	G	P	N	N	N
Woolly cupgrass	G	G	F	G	P	P	G	P	P	G	F	F	P	P	N	N	F	F	N	F	N
Wild proso millet	F	F	F	F/G	P/F	P	F	P	P	F	F	F	P	P/F	N	N	P	F	N	F	N
Wild oat	P	P	F	F	F	G	P	G	N	P	F	P	G	F	N	N	G	F	N	F	N
Sanbur	F	F	G	G	F	F	F	F	P	F	G	P	—	F	P	P	P	—	P	G	N
Broadleafs—																					
Buffalo bur	P	P	F	G	P	P	P	P	P	P	P	P	P	P	P	P	G	F	P	P	—
Cocklebur	N	N	P	P	F	F	N	F	F	N	P	P	P	F	G	G	G	F	G	P	G
Kochia	P	P	P	F	G	G	P	G	F	P	F	P	F	G	F	G	G	G	—	F	G
Lambsquarters	F/P	F/P	P	F/G	G	G	F/P	G	G	F/P	F	P	G	G	G	G	G	G	F	F	G
Mustard	P	P	P	P	G	G	P	G	G	P	P	P	G	G	G	F	G	G	G	P	G
Pigweed	G	G	F	F	F	G	G	G	G	G	F	F	G	F	G	G	G	F	P	F	G
Ragweed	P	P	P	F	G	G	P	G	G	P	P	P	G	G	G	G	G	G	G	P	G
Smartweed	P	P	P	P	G	G	P	G	G	P	F	P	F	G	P	G	G	G	G	F	G
Velvetleaf	P	P	F	F	F	F	P	F	F	P	F	P	F	F	G	G	F	F/G	G	F	G
Wild sunflower	P	P	P	P	F	F	P	F	F	P	P	P	P	F	F	G	G	F/G	G	P	G
Canada thistle	N	N	N	N	P	P	N	P	N	N	N	N	N	P	F	G	F	P	F	N	N
Jerusalem artichoke	N	N	N	N	P	P	N	P	P	N	N	N	P	P	G	G	P	P	P	N	N
American germander	N	N	P	F	P	P	N	P	P	N	N	N	P	P	P	P	G	F	P	N	N
E. black nightshade	F	F	P	P	G	G	G	G	F	G	P	P	P	G	F	F	G	G	P	P	—

[1]G=Good; F=Fair; P=Poor; N=None

Effectiveness of herbicides on major weed in soybeans

	Preplant incorporated								Preemergence								Postemergence							
	Alachlor (Lasso)	Chloramben (Amiben)	Ethalfluralin (Sonalan)	Metolachlor (Dual)	Metribuzin (Sencor or Lexone)	Pendimethalin (Prowl)	Trifluralin (Treflan)	Vernolate (Vernam, Reward)	Alachlor (Lasso)	Chloramben (Amiben)	Chlorpropham (Furloe Chloro IPC)	Naptalam (Alanap-L)	Dinoseb (Premerge)	Linuron (Lorox)	Metolachlor (Dual)	Metribuzin (Sencor or Lexone)	Acilluorfen (Blazer)	Bentazon (Basagran)	2,4-DB (Buloxone or Butyrac 200)	Diclofop (Hoelon)	Dinoseb (Premerge)	Naptalam (Alanap I)	Fluazitop (Fusilade)	Sethoxydim (Poast)
Soybean tolerance	G	G	F/G	G	F	F/G	F/G	F	G	G	G	P	G	F	G	F	F	G	P	G	P	G	G	G
Grasses—																								
Giant foxtail	G	G	G	G	F	G	G	G	G	G	P	P	P	F	G	F	P	N	N	G	P	P	G	G
Green foxtail	G	G	G	G	F	G	G	G	G	G	P	P	P	F	G	F	P	N	N	G	P	P	G	G
Yellow foxtail	G	G	G	G	F	G	G	G	G	G	P	P	P	F	G	F	P	N	N	F	P	P	G	G
Barnyardgrass	G	G	G	G	F	G	G	G	G	G	P	P	P	F	G	F	P	N	N	G	P	P	G	G
Wild proso millet	F	F	F	F	P	F	F	F	F	F	P	P	P	P	F	P	P	N	N	P	P	P	G	G
Nutsedge	G	P	N	G	P	N	N	G	F	P	N	P	P	P	F	P	P	F	N	P	P	P	N	N
Woolly cup grass	G	G	G	G	P	G	G	F/G	G	G	P	P	P	P	G	P	P	N	N	P	P	P	G	G
Quackgrass	N	N	P	N	P	P	P	F	N	N	N	P	N	P	N	P	N	N	N	N	P	N	F	F
Sandbur	F	P	G	F	P	G	G	G	F	P	—	P	P	P	F	P	P	P	P	P	P	P	—	—
Broadleafs																								
E. black nightshade	F	F	F	F	P	P	P	P	G	G	P	P	F	P	G	P	G	F	P	N	F	P	N	N
Hairy nightshade	F	P	—	F	P	P	P	P	G	G	P	—	—	—	G	P	F	F	—	N	—	—	N	N
Cocklebur	P	P	N	N	F	N	N	P	N	P	P	P	G	P	N	F	F	G	F	N	F	P	N	N
Kochia	P	G	G	P	G	G	G	—	P	G	P	F	F	F	P	G	—	F	—	N	—	F	N	N
Lambsquarters	F/P	G	F/G	F/P	G	F/G	F/G	F	F/P	G	P	—	F	G	F/P	G	P	F	P	N	P	P	N	N
Mustard	P	F	P	P	G	N	N	F	P	F	F	—	G	G	P	G	G	G	P	N	G	—	N	N
Pigweed	G	G	G	G	G	G	G	G	G	G	P	F	F	G	G	G	G	P	P	N	P	—	N	N
Common ragweed	P	G	N	P	G	N	N	P	P	G	P	—	F	G	P	G	G	G	P	N	F	—	N	N
Giant ragweed	P	F	N	P	F	N	N	P	P	F	P	—	—	F	P	F	G	F	F	N	—	—	N	N
Smartweed	P	G	P	P	G	F	P	P	P	G	G	—	F	F	P	G	G	G	P	N	G	—	N	N
Velvetleaf	P	F	N	P	F	F	N	F	P	F	P	P	P	F	P	F	P	G	P	N	P	P	N	N
Venice mallow	P	G	P	P	G	P	P	G	P	G	P	—	—	G	P	G	F	G	P	N	—	—	N	N
Wild sunflower	P	P	N	P	F	N	N	P	P	P	P	—	F	P	P	F	F/G	G	P	N	F	—	N	N
Canada Thistle	N	N	N	N	P	N	N	N	N	N	N	P	P	P	N	P	P	G	P	N	P	P	N	N

G = Good, F = Fair, P = Poor, N = No control, — = Insufficient information

Effectiveness of herbicides on major weeds in sugar beets

	Preplanting				Preemergence or Preplanting			Postemergence				
	Diethatyl (Antor)	Cycloate (Ro-neet)	Diallate (Avadex)	EPTC (Eptam)	Ethofumesate (Nortron)	Pyrazon (Pyramin)	TCA	Barban (Carbyne)	Dalapon (Dowpon, Baslapon)	Endothall (Herbicide 273)	Desmedipham (Betanex)	Desmedipham Phenmedipham (Betamix)
Sugar beet tolerance	G	G	G	F	G	G	G	G	F	F	F	F
Grasses—												
Giant foxtail	F/G	G	P	G	G	P	G	P	G	P	P	F
Green foxtail	F/G	G	P	G	G	P	G	P	G	P	P	F
Yellow foxtail	F/G	G	P	G	P	P	G	P	G	P	P	F
Barnyardgrass	P/F	G	P	G	P	P	G	P	G	P	P	P
Wild oat	P/F	F	G	F	F	P	P	G	F	P	P	P
Broadleafs—												
Common ragweed	P	F	P	F	P	G	P	P	P	F	G	G
Lambsquarters	P	F	P	F	F	G	P	P	P	P	G	G
Marshelder	P	P	P	P	P	P	P	P	P	G	P	P
Pigweed	G	F	P	F	G	G	P	P	P	F	G	P
Smartweed	P	P	P	P	G	G	F	P	P	G	F	F
Wild buckwheat	P	P	P	P	G	G	P	P	P	G	F	G
Wild mustard	P	P	P	P	P	G	P	P	P	P	G	G
Volunteer sunflower	P	P	P	P	P	P	P	P	P	F	P	P
Kochia	P	P	P	F	G	F	P	P	P	P	P	F
Common cocklebur	P	P	P	P	P	F	P	P	P	P	F	G

G=Good; F=Fair; P=Poor

Effectiveness of herbicides on major weeds in small grains and flax[1]

	Small grains													Flax						
	trifluralin (Treflan)	triallate (Far-go)	diallate (Avadex)	2,4-D amine or ester	MCPA amine or ester	bromoxynil (Brominal/ Buctril)	dicamba (Banvel)	picloram (Tordon 22K)	barban (Carbyne)	difenzoquat (Avenge)	diclofop (Hoelon)	propanil (Stampede)	chloroxuron (Glean)	MCPA aminelester	bromoxynil	dalapon (Dowpon)	barban (Carbyne)	diallate (Avadex)	EPTC (Eptam)	trifluralin (Treflan)
Crop Tolerance—	F	F	F	G	G	G	F	F	F	F	F	F	G	F	G	F	G	G	F	F
Grasses—																				
Green foxtail	G	N	N	N	N	N	N	N	N	N	G	G	G	N	N	G	N	N	G	G
Yellow foxtail	G	N	N	N	N	N	N	N	N	N	F	G	G	N	N	G	N	N	G	G
Barnyardgrass	G	N	N	N	N	N	N	N	N	N	G	G	G	N	N	G	N	N	G	G
Wild oat	P	G	G	N	N	N	N	N	F	G	G	P	P	N	N	F	G	G	F	P
Broadleafs																				
Wild mustard	N	N	N	G	G	F	P	P	N	N	N	F	G	G	F	N	N	N	P	N
Wild buckwheat	P	N	N	F	F	G	G	G	N	N	N	G	G	F	G	N	N	N	P	P
Lambsquarters	G	N	N	G	G	G	G	F	N	N	N	G	G	G	G	N	N	N	F	G
Pigweed	G	N	N	G	G	G	G	F	N	N	N	G	G	G	G	N	N	N	F	G
Smartweed (annuals)	P	N	N	F	F	G	G	P	N	N	N	P	G	F	G	N	N	N	P	P
Common ragweed	N	N	N	G	G	G	G	F	N	N	N	P	G	G	G	N	N	N	F	N
Giant ragweed	N	N	N	G	G	G	G	F	N	N	N	P	G	G	G	N	N	N	P	N
Kochia	P	N	N	G	G	G	G	F	N	N	N	F	G	G	G	N	N	N	P	P
Marshelder	P	N	N	G	G	G	G	F	N	N	N	P	—	G	G	N	N	N	P	P
Canada thistle	N	N	N	F	F	N	G	P	N	N	N	N	G	F	N	N	N	N	N	N
Perennial sowthistle	N	N	N	F	F	N	G	P	N	N	N	N	F	F	N	N	N	N	N	N

G=Good; F=Fair; P=Poor; N=No control; —=Insufficient information

[1]Effectiveness anc cropt tolerance ratings apply if herbicide is used according to label recommendations as to rate, time of application, etc.and if favorable temperature and moisture conditions prevail.